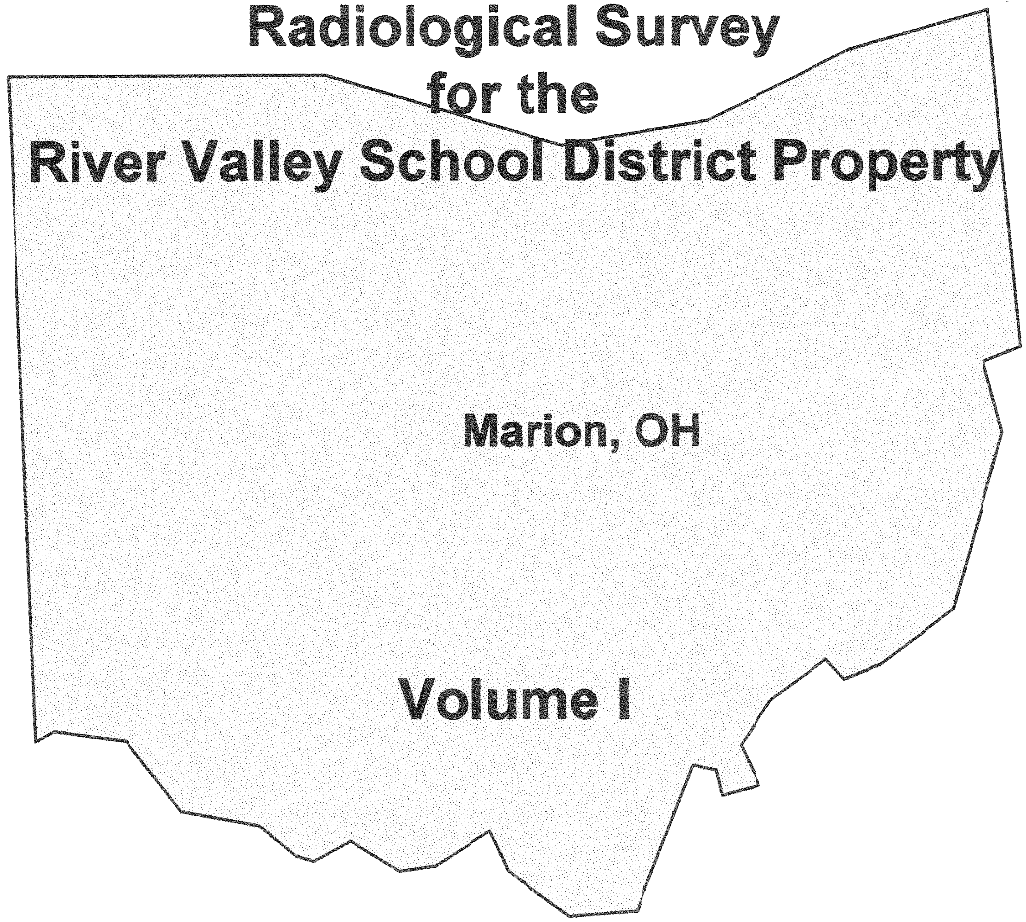
Radiological Survey for the River Valley School District Property



Marion, OH

Volume I

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Site History

From 1942 until 1961 the U.S. Army operated the Marion Engineering Depot (MED) near Marion, Ohio. The mission of the MED was storage, maintenance, and distribution of military engineering and construction equipment. Included in the various types of equipment at this facility were luminous devices containing small quantities of radioactive material (radium 226 (Ra-226)). During the 1961-62 school year, the River Valley School District (RVSD) of Marion County acquired a portion of the former MED property. Administrative offices of the school district, River Valley High School, River Valley Middle School, and associated athletic facilities currently occupy that portion of property. A portion of the RVSD property remains undeveloped.

In July 1997, based on a concern about a seemingly high incidence of cancer among former students of the River Valley High School, the Ohio Department of Health evaluated health data and noted an increased incidence of leukemia. As a result of that finding, the Ohio Department of Health and the Ohio Environmental Protection Agency (OEPA) initiated an environmental investigation of the RVSD site. The Bureau of Radiation Protection of the Ohio Department of Health conducted a radiological scoping survey of the school buildings and grounds in August 1997. That survey identified two small radioactive sources inside the High School. These sources were used for educational purposes and were not associated with former MED operations. The survey also identified a small Ra-226 disk-shaped source in the soil outside the school building. This source was one of the luminous devices referred to above. The U.S. Army Corps of Engineers (USACE) removed the source in September 1997, and performed limited additional radiological surveys at that time. The removal action and results of additional radiological surveys are described in a November 1997, report of the Corps of Engineers for Radiation Survey No. USACESWT-SO-R1-09-97 (Ref. 1). As a result of the health effects evaluation and the discovery of the small radioactive source, the USACE retained the services of Montgomery Watson to perform a comprehensive environmental evaluation.

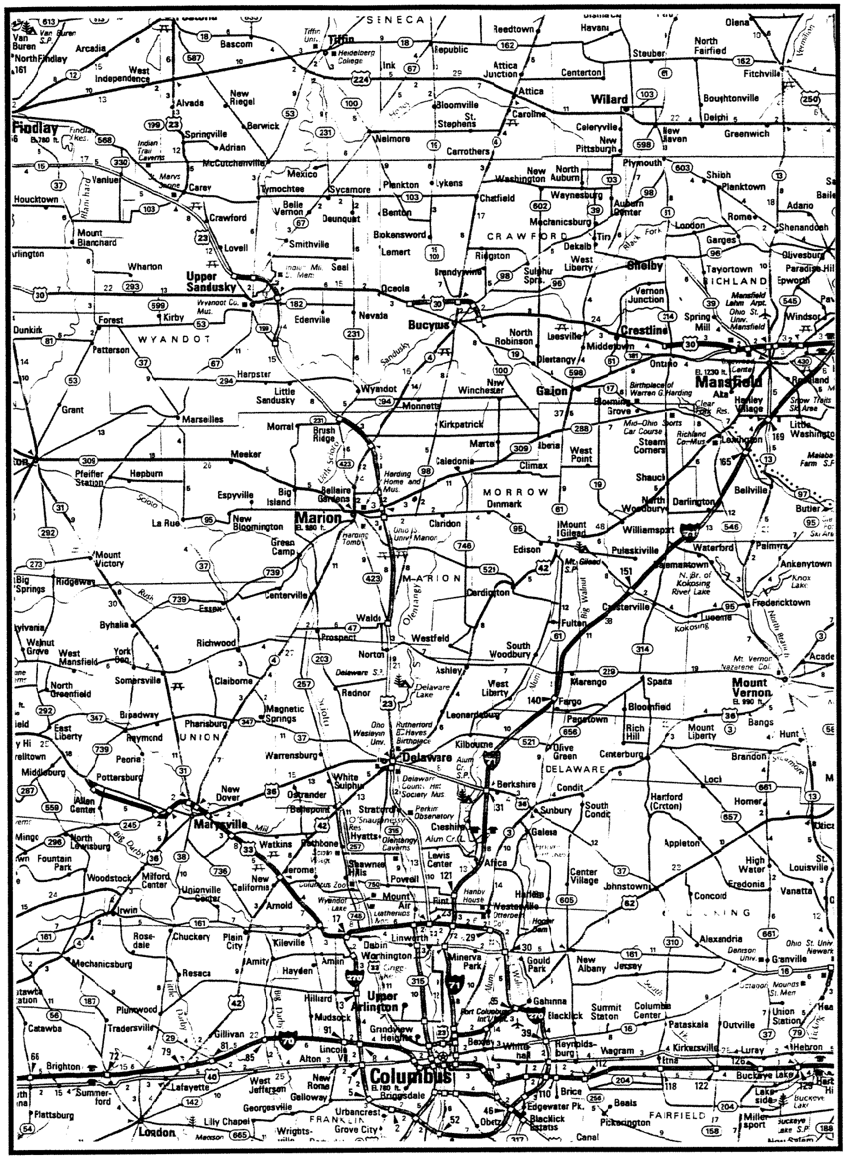
Montgomery Watson procured the services of the Safety and Ecology Corporation (SEC) of Knoxville, TN, to oversee and implement the radiological portion of the evaluation. SEC is a company specializing in environmental radiological restoration. SEC mobilized a radiological team of industry experts and field technicians to design, implement, and complete the investigation.

This report details the logic behind the radiological survey design, describes the survey methodology, and evaluates the final outcome of the investigation.

Site Description

The RVSD property is at the intersection of State Highways 309 and 98, approximately 2 miles (3.2 kilometers) east-northeast of Marion, Ohio (see Figures 1 and 2). The site occupies approximately 78 acres (31.6 hectares) at the northeast end of the original 645 acre site. Structures include 4 major classroom buildings, a building housing district administrative offices, and several buildings housing maintenance and miscellaneous support activities. There are athletic facilities for baseball, softball, soccer, football, tennis, and track, and paved parking areas and roads (Figure 3). The terrain is generally level and, with the exception of approximately 20 acres of natural preserve area along the southwest edge of the property, was readily accessible. Tall grass and weeds were removed from the agricultural and outer ball fields, and the natural preserve area was cleared of heavy brush prior to the survey.

A review of operating history of the site lead to the identification of areas used by MED for shallow landfill disposal. Geophysical investigations and trenching confirmed subsurface anomalies; however, historical information and recent intrusive investigations did not identify the presence of radioactive sources from former MED operations in the disposal areas.



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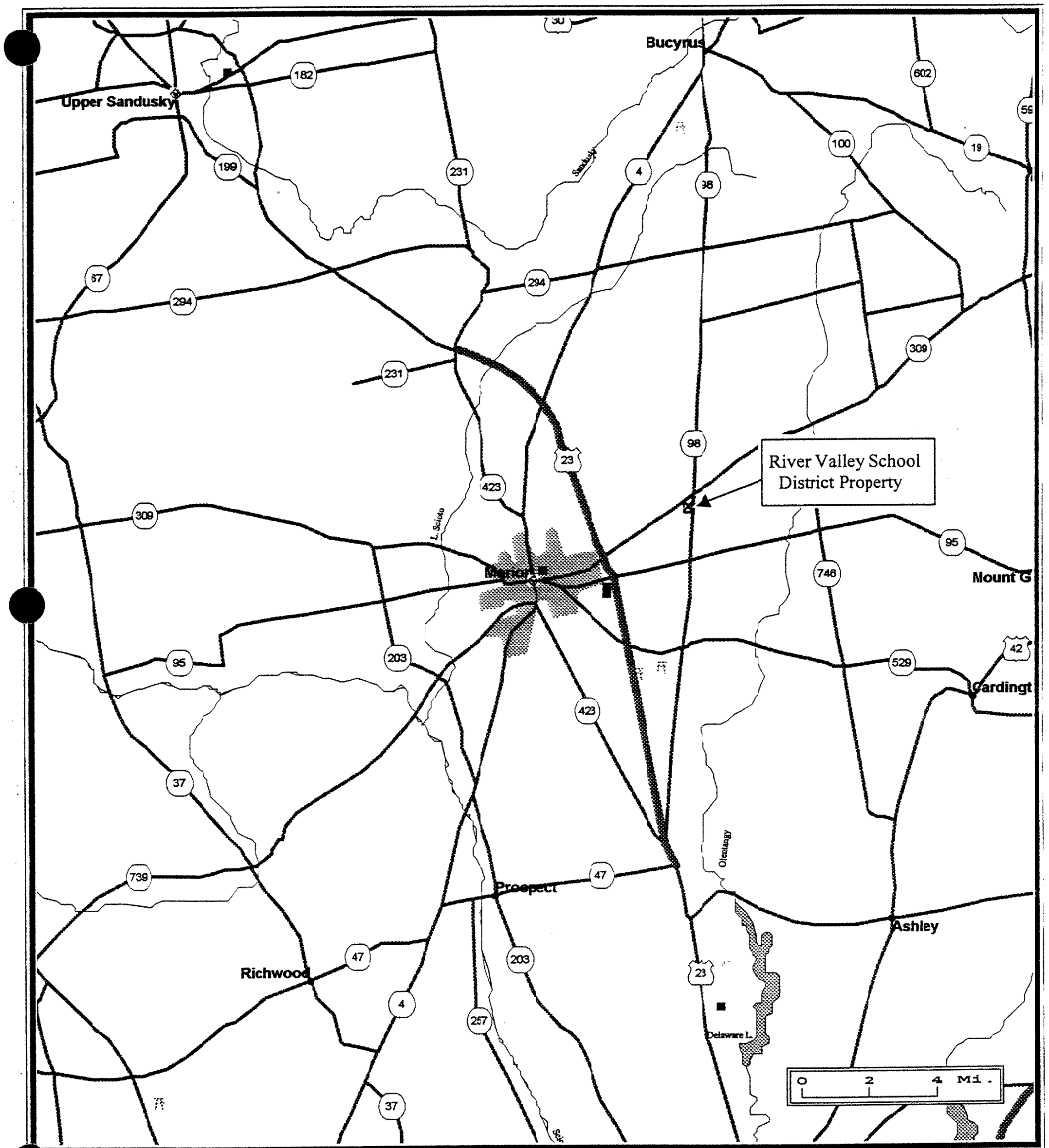
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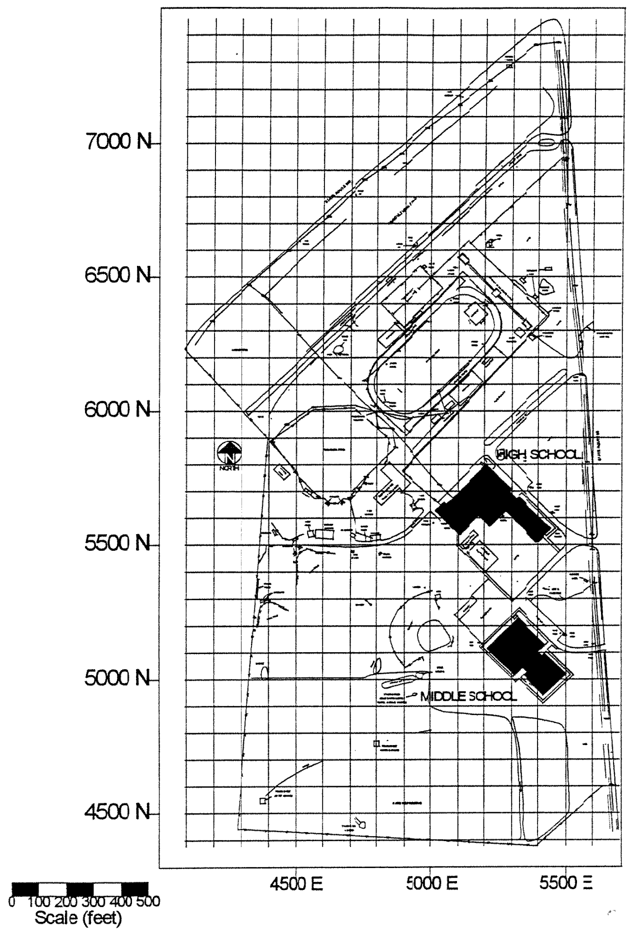


RIVER VALLEY SCHOOL - RADIOLOGICAL
INVESTIGATION - BASE MAP

SAFETY AND ECOLOGY CORPORATION KNOXVILLE, TENNESSEE	U. S. ARMY CORPS OF ENGINEERS LOUISVILLE DISTRICT
DRAWN BY: LAWHON & ASSOCIATES, Inc. WESTERVILLE, OHIO	MONTGOMERY WATSON DETROIT, MICHIGAN

Purpose and Scope

The purpose of the survey was to evaluate the radiological conditions of the RVSD property. The evaluation was limited to the RVSD grounds. Radiological surveys of the buildings have been conducted previously by the State of Ohio. The survey was designed to identify the presence of discrete sources of Ra-226 (or other gamma-emitting radioactive material) within the upper 6 to 12 inches of soil. Areas of soil containing diffuse Ra-226 contamination would also have been identified. The radiological conditions at the RVSD were evaluated relative to criteria established by the State of Ohio Bureau of Radiation Protection, for facility and site use without radiological restrictions.

SEC was fully prepared to evaluate and remediate any residual radioactive materials encountered. However, with the exception of the residues left from the 1997 source removal process (Ref. 1) no residual contamination was discovered.

Survey Overview

The MARSSIM (Multi-Agency Radiation Survey and Site Investigation Manual) process was used for designing, implementing, and evaluating the radiological survey. This process, developed collaboratively by the Nuclear Regulatory Commission, Environmental Protection Agency, Department of Energy, and Department of Defense, emphasizes the use of Data Quality Objectives and Data Quality Assessment processes, along with a sound quality assurance/quality control program. The "graded approach" concept was also used to assure that the greatest survey efforts were commensurate with each areas probability for residual contamination or potential for adverse impacts of residual contamination.

Certain aspects of MARSSIM are intended for application with dose-based guideline levels of residual contamination, implemented by averaging over an entire "survey unit." The criteria of the State of Ohio for Ra-226 in soil was adopted from the Environmental Protection Agency (EPA) uranium mill tailing standards and general Naturally Occurring Radioactive Material (NORM) guidance levels; that criteria is not dose-based and is implemented as an average over a surface area of 100 m^2 (1075 ft^2). The State of Ohio criteria for Ra-226 in soil also does not address additional limitations for small isolated areas of elevated concentrations of the contaminant. The survey design therefore deviated in some respects from the MARSSIM approach, but provides a level of thoroughness and technical soundness that equals or exceeds that of MARSSIM.

To be consistent with a previously developed grid reference system and to provide a more user -friendly Plan and Final Report, the English system of units was used for this project; metric unit equivalents are included at some locations for comparison. Radiological data are presented in "special" units, rather than international units, to be consistent with terminology in which the criteria and standards are defined.

The survey plan was based on information available at the time of the plan preparation. It was recognized that additional historic information on site operations, conditions encountered at the time of the survey implementation, and results of the survey itself, may necessitate modifications in the work plan. Modifications were documented and approved as they were made.

Initial determinations of radiation levels associated with discrete sources of Ra-226 and diffuse Ra-226 contamination in soil were performed using the MicroShield computer code. Detection sensitivities for various aspects of the survey were estimated on the basis of those determinations, nominal values for instrument response and background, and literature values for survey instrument capabilities. Refinements to these detection sensitivity estimates were planned to be made on the basis of actual instrument response to Ra-226 in surface and near-surface soil and background data gathered during site survey preparation and implementation activities. As it turned out, the only radium activity above typical background concentrations was associated with residues of the radium device removed during the summer/fall of 1997 (Ref. 1). This area was too small to perform a proper correlation. Therefore, a final modification to the work plan was made to allow the survey team to travel to a site known to contain residual radium contamination.

To summarize, the pre-survey activities included:

- Re-establishing the reference grid coordinate system used for the earlier geophysical investigations,
- Ground clearing for access as needed,
- Identification of appropriate background area(s) to serve as survey reference locations,
- Determining project-specific background and instrument response factors and refinement of detection sensitivity estimates, as appropriate,
- Training survey personnel in the work plan and applicable procedures.

The field survey activities consisted of:

- Surface gamma scans to identify locations of elevated radiation levels,
- Measurements of gamma radiation levels at 1 meter above the surface for comparison with the derived criterion for unrestricted site use, and
- Collection of composite soil samples to correlate Ra-226 concentrations with gamma exposure levels and demonstrate compliance with the soil contamination criterion.

Survey activities were conducted in accordance with applicable standard operating procedures of SEC (Appendix VI); modifications, additions, or other changes to meet project-specific requirements were documented in the Radiological Survey Work Plan (Appendix IV).

Organization and Responsibilities

SEC, under contract to Montgomery Watson, was responsible for implementation of the survey work plan. SEC's organizational structure (Figure I-4) consisted of Mr. Neil C. Kiely, Project Manager, reporting directly to Mr. Jeff Leblanc of Montgomery Watson; Mr. Frank Myers (SEC), Site Survey Supervisor, Project Health and Safety Officer, and Quality Assurance Officer, reporting directly to Mr. Kiely and Mr. Mike Gilmore of Montgomery Watson. SEC subcontracted with Auxier & Associates, Inc., for the services of Mr. James D. Berger and Ms. Michele R. Landis for technical assistance in survey design, data evaluation, and public presentation of findings. R. Holmes, of Holmes and Ferguson, was contracted by SEC to assist with general health physics consultation and independent project implementation oversight. Ms. Sheryl R. Lambdin, SEC Operations Supervisor, provided post-process data analysis. Lawhon and Associates were contracted by SEC to perform land surveying and drafting.

Radiological Contaminant

The primary contaminant of concern is Ra-226 and associated decay progeny. This contaminant would have likely been in the form of radium bearing paints that were applied to dials, reflectors, and other devices. It was assumed that such devices, containing radioactive materials, might have become displaced on the property. Deterioration of these devices and their radioactive coatings, with time and exposure to the environment, would likely have resulted in localized "hot spots" of soil contamination. There was no indication that the property has been associated with any other radiological contaminants. As a convenience for reviewers, the decay scheme for Ra-226 has been included in this report as Table I-1.

Figure I-4
Organizational Structure

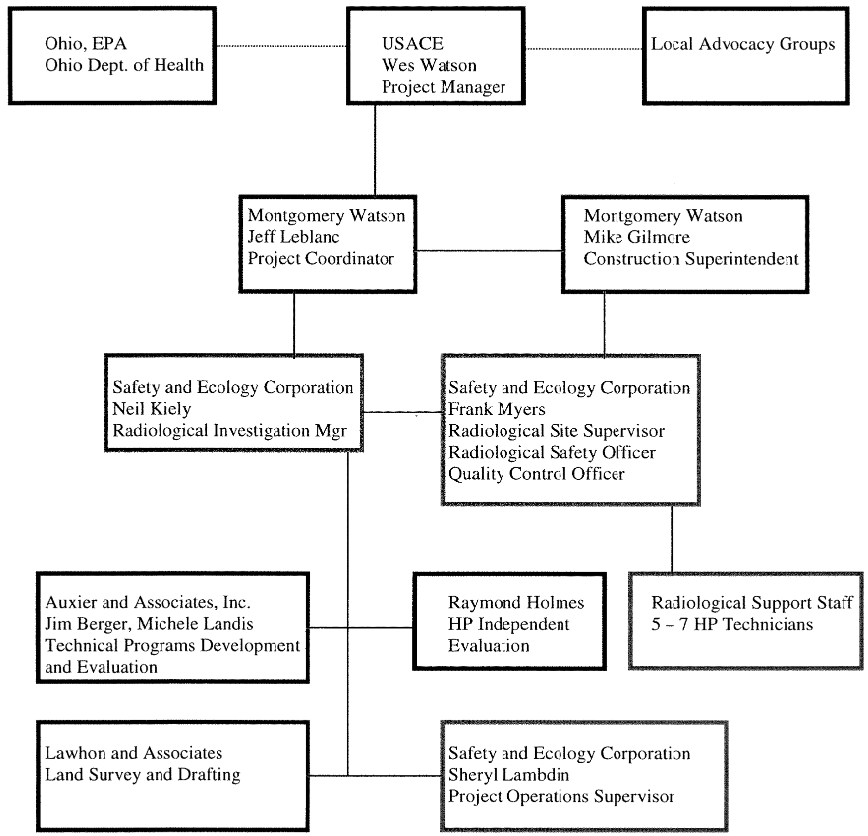


Table I-1
Radium Decay Scheme

		Major Radiation Energies (MeV) and intensities*					
		Alpha		beta		gamma	
Nuclide	Half-life	MeV	%	MeV	%	MeV	%
^{226}Ra	1600 years	5.607 5.716 5.747	24.1 52.2 9.45			144 .154 .269 .324 .338	3.3 5.6 13.6 3.9 2.8
^{222}Rn	3.832 days	6.425 6.55 6.819	7.4 12.1 80.3			.271 .402	9.9 6.6
^{218}Po	3.05 minutes	6.00	100	.33	.02	.837	.0011
^{214}Pb	26.8 minutes			.67 .73 1.03	48 42.5 6.3	2419 .295 .352 .786	7.5 19.2 37.1 1.1
^{214}Bi	19.9 minutes	5.45 5.51	.012 .008	1.42 1.505 1.54 3.27	8.3 17.6 17.9 17.7	.609 1.12 1.765 2.204	56.1 15.0 15.9 5.0
^{214}Po	164 μseconds	7.687	100			7997	.01
^{210}Pb	22.3 years	3.72	.000002	.016 .063	80 20	0.465	4
^{210}Bi	5.01 days	4.65 4.69	.00007 .00005	1.161	100		
^{210}Po	138.378 days	5.305	100			.802	.0011
^{206}Pb	Stable						

* This table presents the U-238 decay chain extending from Ra-226 to the stable isotope of Pb-206. Branching fractions (At-218 at 0.02%, Tl-210 at 0.21%, and Tl-206 at 0.00013%) have not been included in this table. A complete table may be reviewed in The Health Physics And Radiological Health Handbook (Ref. 2).

General Purpose

The purpose of this survey was to evaluate the radiological conditions of the RVSD property. The survey was designed to identify the presence of discrete sources of Ra-226 (or other gamma-emitting radioactive material) within the upper 6 to 12 inches of soil. Areas of soil containing diffuse Ra-226 contamination would also have been identified. The radiological conditions at the RVSD were evaluated relative to criteria, established by the State of Ohio Bureau of Radiation Protection, for facility and site use without radiological restrictions.

State of Ohio Radiological Guidelines

The State of Ohio default criterion for Ra-226 in soil is 5 pCi/g (or less) above background, averaged over the upper 15 cm (6 inches) of soil below the surface and averaged over any 100 m^2 (1075 ft^2) area (Ohio Administrative Code 3701-39-021 (B) (1) (b)). The survey objective was to demonstrate compliance with this criterion, also known as the weighted-average, derived concentration guideline level or $DCGL_W$.

Primary Investigative Method

Surface radiation scans were performed using NaI, 2 inch by 2 inch detectors, which served as the primary investigative tool. These scans were conducted such that 100% of accessible areas were effectively covered. Several gamma-emitting isotopes are contained within the Ra-226 decay scheme. These gamma emitting isotopes are reasonable easy to detect at low concentrations through gross gamma measurements using the NaI, 2 inch by 2 inch, detectors. Thus, the gamma scans provided the qualitative basis for all additional investigations.

Surface scans were recorded in count rate (counts/minute (cpm)). The results of these scans were used to identify locations where direct gamma radiation levels were elevated relative to ambient levels. This was performed by continuously monitoring the relative instrument count rate during scanning through use of the audible response signal.

Investigative Levels

Investigative levels were developed in the first few days of the survey. It was apparent that reference backgrounds for each of the surface materials encountered at the River Valley School would need to be developed. These reference backgrounds for each surface material provided a frame of reference the technicians could use to delineate areas requiring further investigation.

Based upon the reference backgrounds, a multi-layered investigative analysis process was then applied. A brief description of this process follows.

The technicians would scan each survey unit in a systematic pattern so that 100% of the area was effectively covered. Variations in count rate were noted and recorded. Variations within expected background levels for each surface type were also documented. Gamma exposure rate variations, unexplained by surface type, or small areas with a perceptibly elevated radiation rate (potentially indicating a small quantity of localized contamination, or a source at depth) were flagged, noted, or otherwise marked, for further investigation.

Detection Ability at the RVSD Site

Based on a nominal background level of approximately 10000 cpm (10 kcpm) and a Ra-226 response factor of about 1472 cpm/µR/h (Exhibit A, PIC Vs. NaI Correlation Development), it is estimated that an increase in the instrument response of about 1140 cpm above background can be detected (Exhibit B, Minimum Detectable Count Rate Estimate) with a 2 inch by 2 inch scintillation detector in the scanning mode. This is equivalent to being able to detect an increase of less than 1 µR/h above background, over an area of less than 1 m^2, at the 95% confidence level.

Estimations of Required Detection Capability

The Ra-226 source identified by the August 1997 survey was reported by the USACE to have a direct radiation level of 2 mR/h at a distance of 1 meter (3.3 ft). Based on other direct measurement data from the USACE report of the removal action, exposure rate measurements appear to be approximately a factor of 1.6 high (this is consistent with the observed over-response of a gamma scintillation detector calibrated for Cs-137). Based on the gamma-ray constant of 0.825 mR/h at 1 meter from a 1 mCi source of Ra-226, the Ra-226 activity of the source is estimated as approximately 1.5 mCi.

A 1 mCi activity source on the ground surface would have an <u>above-background</u> exposure rate of 1250 µR/h at a distance of 3.3 ft. This would decrease to about 140 µR/h at 10 ft, 35 µR/h at 20 ft, and 15 µR/h at 30 ft. In a background level of less than 14 µR/h (i.e., the maximum ambient background level near buildings) the presence of such a source would easily have been detected at distances well beyond the scanning intervals (about 3 feet).

MicroShield calculations were performed for a 1.5 mCi source of Ra-226 with progeny in equilibrium with various amounts of soil coverage. With 6 inches of soil coverage the above-background exposure rate at 3.3 ft above the ground would be approximately 580 µR/h; at 12 inches the calculated level would be 180 µR/h and at 18 inches the level would be approximately 5.6 µR/h. On the basis of these calculations it would be easily possible to identify a source, similar to the one described in the USACE report, at a depth of up to 18 inches of soil, based on the increase of direct gamma levels above typical ambient background levels.

The estimated detection sensitivity for the Ludlum Model 2221/44-10 instrument combination in the scanning mode is 2.8 pCi/g above background for small areas (about 2.6 ft^2) of diffuse soil activity (Table 6.3 of NUREG-1507 (Ref 3)). The combination would be more sensitive for larger areas of contaminated soil. The scan procedure would therefore be capable of identifying areas of soil with Ra-226 contamination that equals or exceeds the criterion of the State of Ohio.

Exposure Rate in Relation to Radium Contamination level

Exposure rates in µR/h were used as a surrogate measurement to demonstrate compliance with the criterion for Ra-226 in surface soil. The above-background exposure rate at 3.3 ft above the surface associated with a homogenous concentration of 5 pCi/g of Ra-226 (plus progeny), above background, over a 6 inch depth and 100 m^2 (1075 ft^2) was calculated using MicroShield. The resulting exposure rate is 6.1 µR/h.

Measurements of integrated counts in 0.5 minutes were performed at 10 "data point" locations using the Ludlum Model 2221/44-10 instrument combination. The number and location of measurements were selected based upon MARSSIM statistical requirements (Exhibit C, Determination of Data point Requirements) in combination with the MARSSIM recommended random-start, triangular grid method (see Fig. VIII-1). Count rate were converted to exposure rate (µR/h) using correlations determined by intercomparison with a Pressurized Ionization Chamber (Exhibit A, PIC vs. NaI Correlation Development).

Results of exposure rate surveys for each survey unit were tested using the non-parametric statistical approach recommended in MARSSIM. The results of these tests are found in Appendix I, Wilcoxan Rank Sum Results.

Soil Sampling Parameters

Fifty soil samples were collected from 100 m^2 (1075 ft^2) areas. The sample locations were selected using the random-start, square grid pattern. These were composite-type samples in that a single sample was made up of nine separate 0 to 6 inch soil plugs from a single sample location. These samples were analyzed by gamma spectrometry by the Quanterra Corporation in Richland, Washington for Ra-226 content.

Sample results are reported in units of pCi/g, dry weight. The result of each individual composite sample was compared directly with the State of Ohio criterion. These results were also tested for compliance at the 95% confidence level, using the Student t-test approach of NUREG/CR-5849 (Ref. 4). These results and comparisons are found in Exhibit F, Final Soil Analysis Results.

Survey Data Quality Objectives

In accordance with recommendations of MARSSIM, SEC used non-parametric statistical tests for this survey project. This comparison was performed using the Wilcoxan Rank Sum test because Ra-226 is naturally occurring in background.

Primary to the non-parametric statistical test is the establishment of data quality objectives prior to the collection and evaluation of data. These objectives are outlined below.

- As part of the Data Quality Objective (DQO) process the null hypothesis is stated -- the null hypothesis (H_0) states that residual contamination exceeds the acceptance criterion; by rejecting the null hypothesis, the alternative hypothesis must be accepted and the findings of the site evaluation satisfy the acceptance criterion.

- The Type I (alpha) decision error was chosen to be 0.05; this provided a confidence level of 95% that the statistical tests did not incorrectly determine that a surveyed area satisfied criteria when, in fact, it did not.

- The Type II (beta) decision error was chosen to be 0.05; this provided a confidence level of 95% that the statistical tests did not incorrectly determine that a surveyed area did not satisfy criteria when, in fact, it did. The Type II decision error is more restrictive than is usually recommended for such surveys. This more restrictive value typically has a potential consequence of indicating unnecessary remediation. However, considering that the anticipated form of the contaminart at the RVSD should not result in borderline decisions and considering the public relations consequences of failing to identify residual contamination, it was decided that the more restrictive level was prudent.

Data quality indicators for precision, accuracy, representativeness, completeness, and comparability were established as follows.

- Instrumentation precision and reproducibility were determined on going by comparisons of daily operational checks with a pre-established acceptable range. Soil analysis replicates were performed on 5% of the samples. The objective was a relative percent difference of 30% or less, at 50% of the criterion value. This objective had to be changed to ± 30% at or near background level since little or no residual contamination was identified on site.

- Accuracy is the degree of agreement with the true or known; the objective for this parameter was +/- 20% at 50% of the criterion value. On-site instrumentation accuracy was measured through daily performance checks. The criterion value was changed to the predetermined response average.

- Representativeness and comparability do not have numeric values. Performances for these indicators are assured through the selection and proper implementation of systematic sampling and measurement techniques.

- Completeness refers to the portion of the data that meets acceptance criteria and is therefore useable for statistical testing. The objective is 90% for this project.

Introduction

A substantial portion of this report is spent on discussions of background radiation, background measurements, and " typical" background. This is due to the MARSSIM survey approach, which makes use of the idea of a reference area (i.e., a background area) as a comparative tool. This requires that the background units be truly comparative and reasonably applicable. This section provides a discussion on how the River Valley School District background radiation levels were derived and the summarized results

The application of background measurements

The initial survey plan called for the establishment of a single reference survey unit. However it became apparent that a straight forward, side-by-side, comparison would be difficult (not reasonably applicable). The primary reasons for this are discussed below.

> Due to the sensitive nature of this survey, it became apparent that normal variations in background, which are commonly disregarded in comparable surveys, might become a point of contention at the River Valley School site.
>
> The MARSSIM concept of a "survey unit" relies on deviations in homogeneity to indicate potential problem areas. This was a problem at the school because a large percentage of the survey units contained multiple surface materials; all of which have differing background radiation characteristics. To achieve homogeneity the survey unit boundaries would have had to conform to the boundaries of the differing surfaces. This obviously would have slowed the survey process down considerably without increasing detection ability and would have resulted in a Final Survey Report that was unnecessarily confusing.

For these reasons, survey units at the school were allowed to consist of the differing surface types. A composite of surfaces was used as the reference (background) area for comparisons – the only exception being those units surrounding brick buildings. The composite reference unit was made up from a combination of actual measurements from asphalt, concrete, gravel, and grass surfaces. A brick-building-influenced, reference unit was also developed for survey units surrounding buildings. Brick typically contains naturally occurring radioactive materials in quantities slightly higher than what is found in typical soil. As a result, direct radiation levels near brick structures are slightly higher than those near other surface materials.

Summarized results of the background surveys are presented in Tables V-3, V-4, V-5 and V-6. The Field Survey Reference Area Forms, from which the composite background data were derived, are found in Appendix III, Part 3.

Sodium Iodide (NaI), Background Radiation for Buildings

The left side of TableV-3 was derived during the start-up phase of the project. As the investigation progressed it was decided to form survey units around the large brick buildings at the River Valley School site. This decision was made because of the enfluence brickbuilding had on background exposure rates for grass, asphalt, and concrete. Fundamental to the statistical approach of a MARSSIM survey is the idea of a homogenous survey unit. It was therefore necessary to make this adjustment. The building survey units were comprised of the zone extending from the brick wall, out to 20 feet. It is apparent that the exposure rates listed on the left side of Table V-3 were taken between 3 feet and contact of building surfaces. This is standard industry practice when conducting a dose rate survey. However, the measurements taken at 1, 3, 5, 6, 10, 15, and 20 feet (the right side of the table) are more representative of the survey unit designed for this investigation.

TableV-3

2 inch by 2 inch NaI(Tl) Background Data from the Marion Ohio, Reference Area.

	Brick Building (cphm)				Brick building - at 1', 3', 5', 10', 15' and 20' (cphm)						
	*97809	103942	138356	103977	1 foot	3 feet	5 feet	6 feet	10 feet	15 feet	20 feet
1	8588	7304	8062	6404	8494	6517	6301	5979	6303	5900	5858
2	8176	6766	7081	6654	8887	6873	6545	5989	6197	5905	5714
3	7934	6959	6536	7034	8127	7026	5857		4159	5747	3865
4	8175	8948	7571	7350	8033	7252	5917		4374	6058	3977
5	8158	7176	7802	8551		5472	5725		5743	4478	4367
6	6450	8195	5858	7828		5492	5681		5663	4729	4316
7	6554	6120	7168	5536					5718		5558
8	6275	7708	6331	6283					5783		5526
9	7299	6342	6493	6477					4159		
10	6912	6845	6337	6357					4374		
	Average:	7114.93			Average:	5825					
	SD:	832.965			SD:	1188					
	n:	40			n:	42					
	uR/h	13.2698			uR/h	11.52					
	SD	1.1319			SD	1.615					
	* instrument SN										

Sodium Iodide (NaI), Background Radiation for Concrete, Gravel, Asphalt, and Grass surfaces

Table V-4, consists of 10 measurements for each surface type. The 10 measurements chosen to represent each surface material type were selected, at random, from a complete set of 40 individual measurements (four instruments were used to take 10 measurements of each surface type (see Appendix III, Part 3)).

Table V-4

2 inch by 2 inch NaI(Tl) Background Data from the Marion Ohio, Reference Area

Background data in cphm				
No.	Concrete	Gravel	Asphalt	Grass
1	3543	3439	3494	5769
2	3837	3313	3654	5660
3	3698	3190	3747	5379
4	3856	3113	3676	5421
5	4085	3244	3616	5080
6	3871	3192	3832	5093
7	3901	3480	3777	5227
8	3909	3548	3484	5630
9	3950	4531	3672	5744
10	3701	4047	3633	5852
Average:	3835.1	3509.7	3658.5	5486
SD:	152.493	448.3169	111.7798	234.7525

Grass Effects on Background Exposure Rate

All the numbers in Table V-5 are taken from Table V-4. This table demonstrates the effect on exposure rate as the percentage of grass contained within the survey unit is increased.

Table V-5 presents the final background unit that was derived for comparison against all River Valley School survey units – excluding those around brick buildings. This is the unit designated as "50%Grass" in Table V-5. The "50% grass," reference unit is made up of 5 grass surface readings and 5 "non-grass" unit measurements, all from Table 4.

The surfaces which are designated as "non-grass" included asphalt, concrete, and gravel. This means that the reference area designated as "0% Grass" was completely comprized of either asphalt, concrete, and/or gravel. As can be seen in TableV-5, the exposure rates varys from around 9 to 11 µR/h as the precentage of grass is increased from 0 to 100%. The survey units at the River Valley School site were often comprised of a grass/non-grass surfaces. Instead of breaking these units down into sub-units (which would have added detail at the expense of clarity) it was decided to use the derived, 50 percent, grass background as the reference unit for comparison against the River Valley School survey units. Thus the 50% grass numbers, found in table 5, are used in the marjority of Wilcoxan Rank Sum tests found in Appendix I. The only exception to this is those survey units which surround brick buildings.

Table V-5
Effects of Grass Surfaced Areas, as a Percentage of Total Surface Area,
On Gamma Exposure Rates.

	Background Data. Counts in cphm.									
No.	0% Grass		20% Grass		**50% Grass**		70% Grass		100% Grass	
1	3950		3950		3856		5379	*	5769	*
2	4047		4047		5080	*	5421	*	5660	*
3	3494		5769	*	3616		4085		5379	*
4	3837		3676		5098	*	5098	*	5421	*
5	3190		3698		3901		5527	*	5080	*
6	3676		3113		5630	*	3548		5098	*
7	4085		5527	*	4531		5744	*	5527	*
8	3192		3832		5769	*	5852	*	5630	*
9	3777		3901		3633		3654		5744	*
10	3909		3548		5769	*	5852	*	5852	*
Average:	3715.7		4106.1		4688.3		5016		5516	
SD:	326.3		855.0		891.0		904.8		269.8	
	* indicates a grass measurement									
	Background Data in uR/h. See Exhibit A for convertion equation.									
uR/h	8.7		9.2		10.0		10.4		11.1	
+/-SD	0.4		1.2		1.2		1.2		0.4	
+/-2 SD	0.9		2.3		2.4		2.5		0.7	

SD: Standard Diviation at n-1 for the 10 data points

Background Exposure Rate Measurements

Table V-6 presents typical background rates in counts per minute and in µR/h for several differing surfaces at the Marion Municipal Airport.

Table 6
Background Pressurized Ion Chamber (PIC) and
NaI(Tl) 2 Inch by 2 Inch Detector Measurements

Location	Inst. No.	*cpm	**PIC	Location	Instr. No.	*cpm	**PIC
Flag pole	1	10357	10.1	Brick	1	12950	12.6
(Grass)	2	10317	10.1	Building	2	12196	12.6
	3	10286	10.1		3	11832	12.6
	4	10117	10.1		4	13410	12.6
Hanger	1	7775	8.2	Asphalt	1	7494	10.5
Concrete	2	7695	8.2		2	7385	10.5
	3	7698	8.2		3	7520	10.5
	4	7647	8.2		4	7389	10.5
Gravel	1	6936	7.8				
Road	2	6902	7.8				
	3	6982	7.8				
	4	6905	7.8				

* Counts are in counts per minute
** PIC reading in uR/h

Compliance with Guidelines

As part of the DQO process the null hypothesis is stated -- the null hypothesis (H_0) tested is that residual contamination exceeds the acceptance criterion; by rejecting the null hypothesis, the alternative hypothesis must be accepted and the finding of the evaluation is that the site satisfies the acceptance criterion.

In accordance with recommendations of MARSSIM, SEC used non-parametric statistical tests for this survey project. This comparison was performed using the Wilcoxan Rank Sum test because Ra-226 is naturally occurring in background. The results of this evaluation are presented in its entirety in Appendix I, Wilcoxan Rank Sum Results.

A supplemental evaluation of soil sampling results were compared with the Ohio EPA 5 pCi/g criterion, using the Student t-test as described in NUREG/CR-5849.

Area Classification

MARSSIM identifies three classifications of areas, according to contamination potential. Class 1 areas have a potential for contamination that exceeds the criterion; Class 2 areas have a potential for contamination but it is unlikely that it exceeds the $DCGL_w$; Class 3 areas are not expected to contain residual activity in excess of background.

Because the Ohio Bureau of Radiation Protection survey of August 1997 identified a small Ra-226 source on the property, and the geophysical investigation identified multiple subsurface disturbances, the entire property was classified as a Class 1 area, thereby providing the maximum level of survey coverage.

The site was divided into survey units following the general guidance of MARSSIM Section 4.6. The basic configuration for the survey unit was selected to be 100 by 200 feet when possible. This resulted in 171, Class 1 survey units, typically consisting of approximately 20,000 ft^2, being identified. These survey units are presented as Drawing 1, River Valley School Survey Unit Grid System.

Data Collection Requirements

Exposure Rate Measurements

The number of measurements required to complete the Wilcoxan Rank Sum statistical tests was calculated to be 10 measurements per survey unit (See Exhibit C, Determination of Data Point Requirements).

Soil Measurements

To perform the test of composite soil concentrations, the process described in Section 8.5 of NUREG/CR-5849 were used. Section 8.6 of NUREG/CR-5849 provides an initial estimate of less than 10 data points for performing this test. A total of 60 soil samples were taken from the school property. Fifty of these were taken for comparison with State of Ohio criteria. Three of the 50 samples were replicate samples for QC purposes. Six biased samples were taken in support of investigative surveys. One sample was taken at the Marion Municipal Airport to verify previously reported (Ref. 1) background soil concentration levels for Ra-226 in the Marion area.

Data Collection Locations

The grid reference system established for the earlier geophysical investigations was reestablished as the base grid for the radiological survey. This was a 100 by 100 foot, site specific, grid system.

Exposure Rate Locations

All exposure rate measurement points were obtained using a random-start triangular sampling pattern with a grid spacing of approximately 50 by 42 feet between points (this is more clearly presented in Figure III-1, Triangular Grid Establishment). This spacing provided approximately 10 data points per survey unit on average. The number of actual survey points per survey unit ranged from 8 to as high as 15.

Figure VI-1
Triangular Grid Establishment

The base leg of the triangular grid was determined using the following equation.

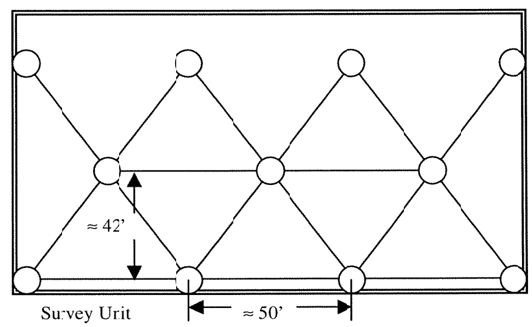
$$L = \sqrt{\frac{A}{0.866n}}$$

Where;
L = Length
A = Area
n = number of data points

Measurement locations

The top of the triangle is located mid-way along the base leg at a distance of 0.866L.

An initial point is randomly selected to begin the lay out.



Soil Measurement Locations

The soil measurements were based upon a 250 by 250 foot square grid, overlaid across the site. Drawing 4, River Valley School Sampling Locations, provides the locations of soil samples.

Instrumentation

The instrumentation used at the River Valley School District site survey consisted of the following:

1) Ludlum Model 2221, scaler / ratemeter with NaI detector
2) Reuter Stokes, Pressurized Ion Chamber RSS-112
3) Ludlum Model 3, count ratemeter
4) Ludlum Model 44-9, GM pancake detector
5) Ludlum Model 43-5, alpha scintillation detector

Specifications and Uses

- **Ludlum Model 2221**

  1) Count rate meter set to the operating voltage and input sensitivity characteristics of the detector in use.
  2) Used as a scaler in continuous and timed collection durations.
  3) Used as the instrument to configure with the Ludlum Model 44-10 and Ludlum Model 43-5 detectors.

- **Ludlum Model 44-10**

  Gamma sensitive, 2"x2" NaI detector capable of identifying minimum levels of < 2.8 pci/gm as referenced in final release of the MARISSM manual, equation 6-10, and NUREC-1507.

- **Reuter Stokes RSS-112**

  1) The RSS-112 is a Pressurized Ion Chamber and is considered a primary standard.
  2) Used to establish scintillator response correlations.

- **Ludlum Model 3**

  1) The Model 3 is an analog count rate meter.
  2) Configured with the Ludlum model 44-9 detector for Beta/Gamma measurements of personnel to verify potential external contamination levels.

- **Ludlum Model 44-9**

  1) The model 44-9 is a Geiger-Mueller tube with an active area of about 15.2 cm^2.
  2) This detector has the ability to detect 5000 dpm/100 cm^2 Beta/Gamma at a distance of ½" from the surface to be measured and at a scan rate of 2 inches/sec.

- **Ludlum Model 43-5**

  1) The model 43-5 is a zinc sulfide impregnated plastic scintillation detector with an active area of 50 cm^2.
  2) This detector has the ability to detect and measure with a digital scaler 20 dpm/100cm^2 at contact with a surface and a measurement count rate time of 60 seconds.

All instruments used were calibrated and certified for use prior to shipment to the River Valley School District site. Daily performance checks were conducted in accordance with individual instrument use procedures. These performance checks were performed prior to, and following, daily field activities and at any time the instrument response was questionable. Only data obtained with instruments satisfying the performance requirements were accepted for use in the evaluation. Calibration and daily performance checks can be reviewed in Appendix V, Instrumentation Calibration and Daily Performance Checks.

Summarized Results and Evaluations

Surface Scans

Surface gamma scans were performed in accordance with SEC Standard Operating Procedure (SOP) 13.0, using a Ludlum Model 44-10 NaI scintillator with a Ludlum Model 2221 scaler/ratemeter at a rate of 0.5 to 1.0 meters per second. The audible instrument response was monitored and used as the primary basis for additional investigation. Each survey unit was sub-divided into 25 x 25 foot scan areas called grids. The gamma response range for each grid was recorded on field-scan, survey log sheets.

Action levels were established to be 3000 cpm over ambient levels for any unexplained, perceptible increase in count rate over background. Detection capabilities are discussed in Part III of this report but are estimated to be around 1140 cpm, or about 1 µR/hr above background. Locations of response exceeding action levels were identified for further investigation. Project-specific forms were used to record data. Coverage was 100% of accessible surfaces. Additional investigations were documented on detail drawings that were attached to the Survey Unit Scan Sheets, Appendix III, Part 1.

The results of these scans are displayed on an engineered site drawing (see Drawing 2, River Valley School Scan Survey Results). The highest scan result found in any grid was used to develop Drawing 2; had this not been the case, small areas (less than 2 m^2) of elevated scan results would not have been large enough to show up on the drawing. In this sense, the drawing is not strictly to scale. However, for the sake of completeness, it was decided that it would be appropriate to indicate the locations of these small-elevated areas, even if they are exaggerated, on the drawing.

A summary table of the scan results has been included in this report as Exhibit D, Scan and Investigative Survey Summary. Exhibit D provides a survey-unit-by-survey-unit summary of average exposure rate, average gamma measurements at one meter, maximum gamma measurement identified, and the results of follow-up investigations.

A reviewer of this report can achieve a very detailed summary of radiological survey results by looking at Drawing 1 and 2, while following the summary provided in Exhibit D.

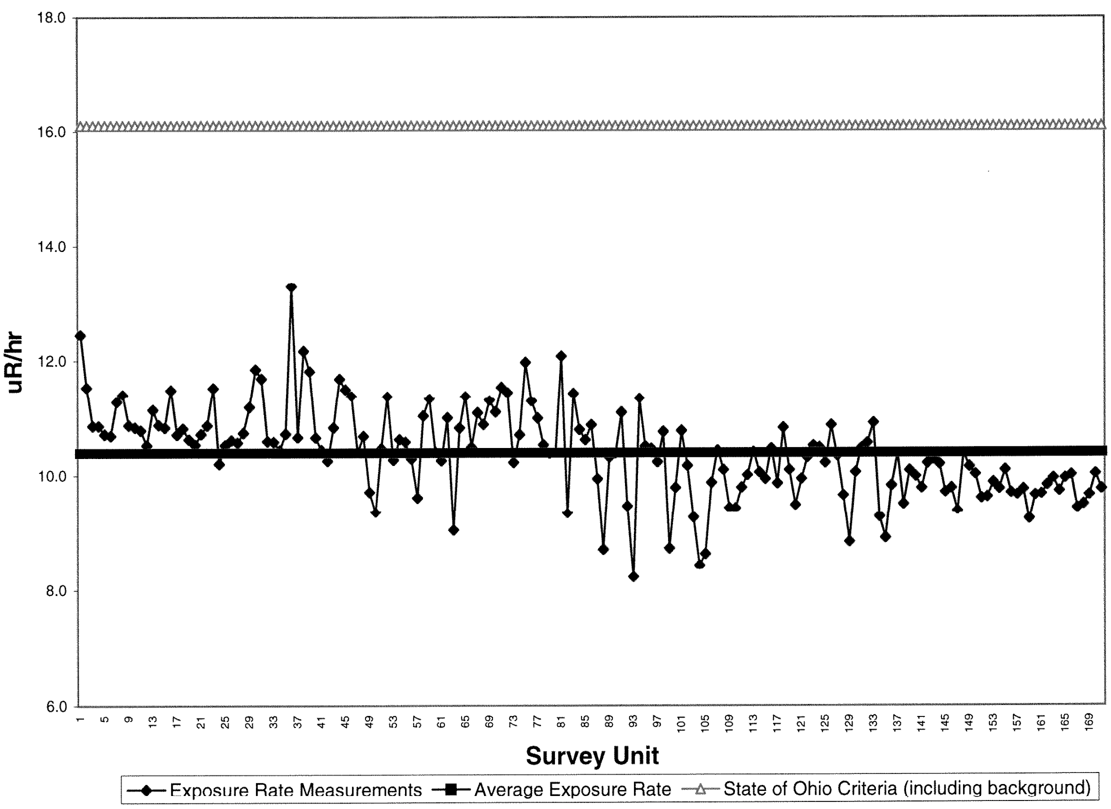
Direct Exposure Rate Measurements

Exposure rate measurements were performed at systematic data point locations in accordance with SEC SOP 28.0, using a Ludlum Model 2221 meter with a Ludlum Model 44-10 gamma scintillation detector. The measurement was performed at 3.3 ft above the surface by integrating the count for 0.5 minutes. A correlation was developed between instrument response and true exposure rate (as measured by a Pressurized Ionization Chamber (PIC)). Project-specific forms were used to document the measurements (see Appendix III, Part 2, Raw Exposure Rate field forms).

Figure VII-1 presents the exposure rate results as compared against the acceptance criterion of background plus 6.1 µR/h. The results of the exposure rate measurements have also been placed onto an engineered drawing (see Drawing 3, River Valley School Exposure Survey Results). It should be noted that this drawing will not have the same resolution of the scan drawing. This was due to a couple of reasons: 1) the drawing is based upon 10 readings per survey unit as opposed to 32 readings for the scan drawing, and 2) the measurements were taken on a random start basis – thus the biased measurements used in the scan drawing do not show up on the exposure rate drawing.

Exposure rate data has been placed into a table that can be reviewed in Exhibit G, "Surface Exposure Rates." Exhibit G provides the average exposure rate for each survey unit in µR/h. This exhibit also provides the standard deviation for each unit, what comparable background exposure rate is expected, the exposure rate criteria, and if the unit has met that criteria.

Figure VII-1 Exposure Data vs. Criteria



Soil Sampling

Composite soil samples representing 100 m^2 (1075 ft^2) of ground surface were collected from approximately 50 locations, evenly spaced throughout the site. Three of the 50 locations were selected for replicate samples. SEC SOP 8.0 was generally followed, with the following modifications. Soil plugs, approximately ¾" in diameter, were obtained to a depth of 6", at 9 systematic locations, within the 100 m^2 area. The plugs were obtained from the area center and from a rectangular pattern, with a 3 m (10 ft) spacing. These 100 m^2 sampling areas coincide with exposure rate measurements taken at the same locations. All plugs from an area were field mixed. Approximately 2.2-pound (1 kilogram) aliquots of each composite were packaged in sturdy plastic containers and uniquely identified.

Soil sample results were compared directly against the State of Ohio criterion (5pCi/g greater than background; background is 1.0 pCi/g). This evaluation was performed at the 95% confidence level using the Student t-test method recommended by NUREG/CR-5849. Figure VII-2 depicts the soil results in contrast to the State of Ohio criteria for radium in surface soils. Soil sample results are presented in Exhibit F, Final Soil Analysis Results. The locations of these soil samples are depicted on Drawing 4, River Valley School Soil Sample Locations.

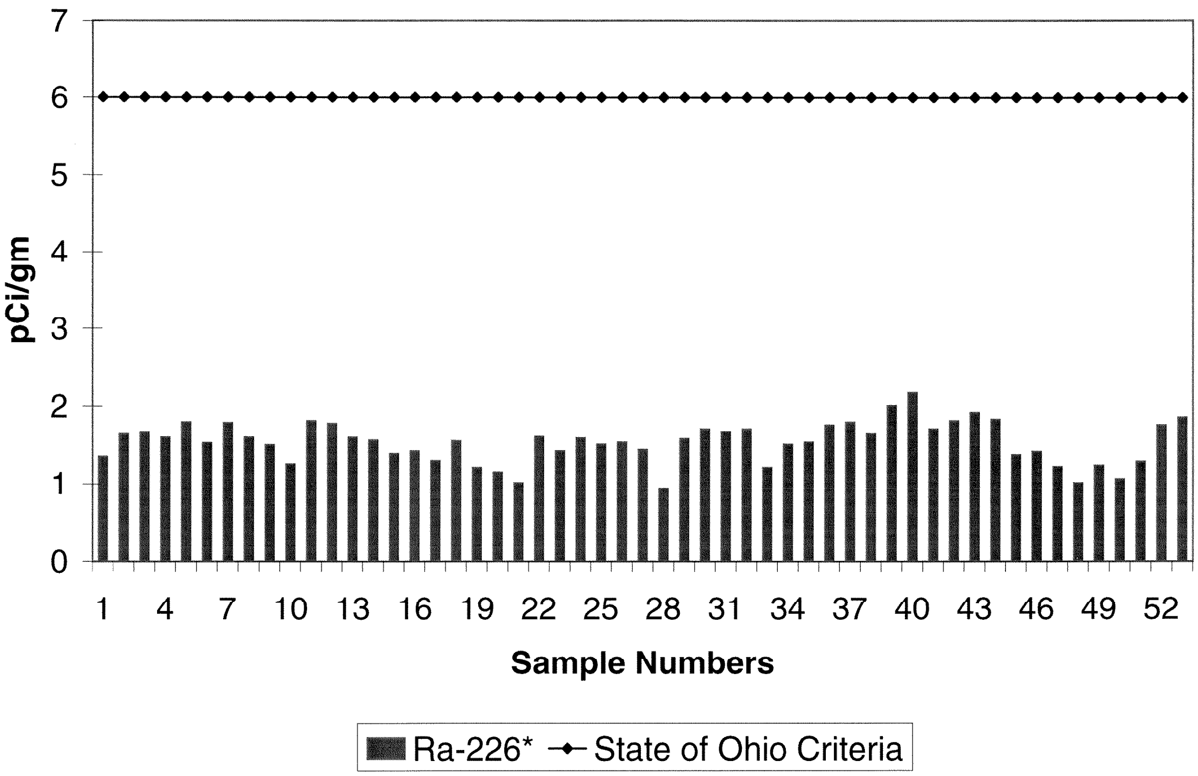
The survey plan called for a site-specific correlation to be established between the soil results and the exposure rate measurements. This was not possible because no variation in contamination, as measured 1 meter above the ground, was ever identified – the source removal area was too small to create a measurable response at one meter. Thus, all exposure rates were at background levels. An X/Y data plot has been developed which shows the measured gamma response, at one meter, for the each composite and biased sample (see Exhibit E, Radium vs. Counts Per Minute). This plot demonstrates that all sample results (other than the sample taken from the source removal area) had radium concentrations ranging from 0.9 to about 1.5 pCi/g. Because a correlation is normally performed using a range of values, this data set would have provided little useful information.

In addition to the 50 composite and 3 replicate soil samples, 6 investigative samples and 1 background confirmatory sample were taken. The results of these additional samples have been included in Exhibit F.

Radioanalytical Analysis of Soils

Soil samples were transferred to a commercial radio-analytical laboratory (Quanterra Labs in Richmond, WA) where they were dried, homogenized, and analyzed for Ra-226 by high-resolution gamma spectrometry. Quantification of the Ra-226 concentration was based on Ra-226 progeny (Bi-214 and/or Pb-214, which ever was higher); an ingrowth period of at least 20 days was used to reach essential secular equilibrium. An initial count without full ingrowth was also performed to obtain preliminary estimates of sample content. Analytical specifications include a minimum measurement sensitivity of 0.5 pCi/g for Bi-214 and Pb-214. Analyses also determined concentrations of K-40 and members of the natural uranium decay series.

Figure VII-2 Soil Sample Results



* Ra-226 concentration derived from equilibrated progeny.

Investigations

Direct radiation levels, identified by scans, that were potentially greater than the equivalent of the Minimum Detectable Concentration (MDC) of approximately 2.8 pCi/g, above background, were investigated for the presence of residual contamination. If survey findings indicated radiological contamination in excess of background but, within the $DCLC_w$ or equivalent criteria, individual judgmental (biased) soil sampling and exposure rate measurements were performed at locations of maximum and representative direct radiation levels to determine the extent and level of contamination.

This investigative threshold resulted in the further investigation of 41 survey units. The results of these investigations fall into the categories listed in Table VII-1. An in-depth discussion of the development and implementation of investigative levels is provided in sections II and III of this report. A summary of the investigative results is provided in the "Results/Comments" section of Exhibit D (Scan and Investigative Results).

Table VII-1
Investigative Results

Cat.	Result	Survey Unit Number
1	Sub-surface measurement triggered the surface investigation level.	3,**35,53, 155,162,164
2	Surface material transition within the survey unit (e.g., Grass to asphalt).	51,77,78,85,100,106,107,114,121, 122,130,**134,136,147,152,157, 163,169
3	The measurement triggering the investigation could not be duplicated.	40,48,60,73
4	Presence of large rock.	168
5	Utility run, bedding material contained within survey unit	**72
6	Abandoned rail line ballast material contained within survey unit.	**43,54,61,**67
7	Residues of the source removed in 1997 contained within the survey unit.	**91

**35: 98RVS054 – Ra-226 = 1.7 pCi/g.
**43: 98RVS055 – Ra-226 = 2.49 pCi/g; U-238 = 12.9 pCi/g.
**67: 98RVS056 – Ra-226 = 2.18 pCi/g; U-238 = 3.11 pCi/g.
**72: 98RVS057 – Ra-226 = 1.46 pCi/g; U-238 = 3.25 pCi/g.
**91: 98RVS058 – Ra-226 = 42.4 pCi/g; U-238 = 3.02 pCi/g.
**134: 98RVS059 – Ra-226 = 1.66 pCi/g; U-238 = 1.27 pCi/g.

Category 1 Discussion "Sub-surface measurement triggered the surface investigation level."

In these units the technicians took advantage of natural features (cracks, ground hog holes, ruts, and, in unit 162, a brick lined drain) to take sub-surface gamma readings. These were documented on the surface scan sheets. The surface trigger level was derived for a measurement over surface plane, which basically measures radiation coming up from the ground. When a probe is placed down a hole, or in a rut, or in a crack, the measured radiation is coming from the walls and from the bottom of the hole. This is referred to as a detector geometry change.

During the investigative process, SEC returned to the Marion Municipal Airport to take down hole gamma readings for comparisons. The readings were taken at 8 inches down three separate ground hog holes. The results ranged from 17000 to 22000 cpm (see Appendix III, Part 3). The subsurface measurments at the River Valley School ranged from 12500 to 22000 cpm. It is concluded then that the sub-surface measurements at the school were within normal expected background levels.

Category 2 Discussion "Surface material transition within the survey unit (e.g., Grass to asphalt)"

Please see "Part V: Radiological Background" of this report. It provides an ample discussion of the effects of differing surface types on background radiation.

Category 3 Discussion "The measurement triggering the investigation could not be duplicated"

There was only 3 units falling into this category each of which is discussed independently below.

Unit 40 – The initial scan produced a maximum count rate of 13900 cpm. The investigative survey maximum count rate was 12200 cpm. Neither of these measurements indicate the presence of contamination. The variation in count rate could simple be due to a variation in survey technique.

Unit 48 – During the survey process, the technicians encountered significantly higher count rates (40,000 cpm) near PVC encased piezometers locations (PVC well heads). At the time of the initial scan survey on 6/20/98, SEC proposed that this was likely due to the affinity radon progeny have toward plastics/synthetics. Wells that are constructed in this manner tend to vent, normally trapped radon gas from soils. This gas gradually builds in the capped well. As the radon decays, radon progeny tend to collect on and within the PVC material. It is the radon progeny which produces the radiation being detected by the 2 inch by 2 inch detector. The half-life for this effect is about 35 minutes – meaning that once the source gas is removed (either by removing the cap or suppressing soil off gassing by flooding the well) the radiation level will diminish, by a factor of 2, every 35 minutes and within 4 hours the radiation rate should return to background levels.

The follow up investigative survey of this survey unit was conducted on 7/15/98. This investigation produced results at normal background levels. The change in radiation level from 40,000 cpm on 6/20/98 to background levels on 7/15/98 seems to support the assumption that the initial measurement was due to radon decay progeny. However, the initial measurement may have due to an error in survey technique or due to an instrument malfunction. In any case, had the radiation measurement been in response to a long lived isotope (i.e., Ra-226) the drop to background in radiation level would not have occurred.

Unit 60 – The initial scan produced a maximum count rate of 13200 cpm over an area approximately 6 x 8 feet. This measurement did not indicate the presence of contamination, more likely there is a slight variation in soil type over this area. The follow up scan indicated that the grid was uniform in count rate.

Unit 73 – The initial scan produced a maximum count rate of 12400 cpm. This measurement did not indicate the presence of contamination. The follow up scan indicated that the grid was uniform in count rate.

Category 4 Discussion "Presence of large rock"

A gamma anomoly of 20,500 cpm was discovered in Survey Unit 168 during the initial gamma scan. During the initial scan the technician removed a few inches of top soil to expose what appeared to be a large rock. During the investigation of this unit, the technicians determined the the rock was approximately 2x3 feet in size. Contact measurements on the rock produced a maximum count rate of 25,600 cpm.

Rock, especially granite or similar hard rock material, typically exhibit radiation levels higher than clay or aggregate soils due to a increased abundance in the natural occurring elements of uranium and thorium. The count rate associated with this rock is completely within the expected count rate for large rocks in general.

Category 5 Discussion "Utility run, bedding material contained within survey unit"

A straight-line anomoly, commonly indicative of bedding materials found in utility runs, was discovered in Survey Unit 72. The highest radiation level discovered along this line was measured at 14,000 cpm (which is just slightly above expected background). A soil sample (98RVS057) yielded results well below State of Ohio criteria.

Category 6 Discussion "Abandoned rail line ballast material contained within survey unit"

Rail line ballast is typically formed from hard rock (uranium and thorium bearing) materials. Soil samples (98RVS055 and 98RVS056) and gamma measurements are supportive of this assessment.

Category 7 Discussion "Residues of the source removed in 1997 contained within the survey unit"

A gamma anomoly was discovered in Survey Unit 91. The USACE was able to confirm that this was the location of the source removal action that occurred in 1997 (Ref. 1). A soil sample taken at this point (98RVS059) also confirmed this assumption.

It should be noted that the residual contamination remaining at this point had contact gamma measurements that are essentially the same as the large rock discovered in Survey Unit 168.

Contact on large rock ...	25,600 cpm.
Contact on residual Contamination ...	25,700 cpm.

It should also be noted that the gamma measurements fell to background levels within 5 feet of the maximum (contact) reading location.

Quality Control

Soil Analysis

Five percent of the soil sampling locations were selected for quality control, replicate, soil sampling. This resulted in 3 replicate soil samples for the River Valley School District survey. The goal for the replicate measurements was selected to be a relative difference of ± 50% at or near background levels. The results of these replicate samples are presented below in Table VII-2.

Table VII-2

Replicate Soil Sample Results

Sample ID	N	E	Bi-214	(2s)	Pb-214	(2s)	U-238	(2s)
98RVS001	4813	5338	1.55	0.21	1.83	0.23	1.46	1.8
98RVS044	4813	5338	1.23	0.18	1.34	0.19	2.79	1.3
Relative % Difference			26%		37%		47%	
98RVS033	7063	5088	1.01	0.13	1.2	0.16	0.29	1.8
98RVS021	7063	5088	1.05	0.15	1.2	0.17	0.56	0.83
Relative % Difference			4%		0%		48%	
98RVS052	6063	4838	1.43	0.19	1.76	0.22	1.15	0.96
98RVS053	6063	4838	1.58	0.2	1.86	0.23	1.51	0.91
Relative % Difference			9%		5%		24%	

Lab Analysis

Quanterra Laboratories performed all gamma isotopic analysis for SEC. This analysis was performed in compliance with Quanterra standard laboratory procedures. Quality Control program documents for the Quanterra Laboratory are presented in Appendix VII-3. The average relative error for the analysis, at 2 standard deviations, is presented in Table VII-3.

Table VII-3
Soil Analysis Parameters

	Bi-214	Pb-210	U-238
Soil Concentration	1.31	1.53	1.42
2s	0.18	0.28	1.35
Releative Error at 2s	14%	18%	95%

This meets the established criteria for the River Valley School District radiological survey for accuracy of ± 20% at 50% of the release criteria.

The majority of lab QA was provided by Quanterra as part of their normal protocol. This included evaluations of data completeness, instrument Calibration, precision (using duplicates, replicates, etc.), cross contamination checks using batch and/or background blanks, and assessment of external QC measurements. Each batch of sample results returned to SEC was accompanied by this analysis plus all sample tracking documentation. A batch analysis narrative detailing any problems encountered was also included. Thus, the complete QA package associated with laboratory analysis (several thousand pages) was far to lengthy to include in this report as an appendix. However, the data is available and can be reviewed at the SEC Corporate Office in Knoxville, Tennessee.

Field Data QA

All field data were reviewed for conformance with indicated procedures and plans as they were gathered. SEC's Radiological Site Supervisor reviewed all data on a daily basis. This same data was faxed to SEC's contract radiological consultant (Ms. M. Landis of Auxier and Associates) who performed the on-going qualitative analysis.

All instrumentation used to perform the scan and exposure measurements was performance checked on a daily basis. The results of these performance checks are provided in Appendix V, Instrumentation Calibration and Daily Performance Checks.

Data Analysis

Trend Analysis

Data from scanning is displayed on a color-coded, engineered drawing (Drawing 3, River Valley School Survey Results), which essentially plots the data in a visual manner. This plot was reviewed for trends or unexpected deviations. Other than an area of slightly lower than expected results in Survey Unit 39, all discernable trends fall in line with expected results for the differing surface materials found at the River Valley School.

Criteria Comparison

The random-start, gamma exposures rate measurements, were converted into units comparable to the criterion established for the River Valley School District property. The criteria derivation is described in Part III, Survey Specifications, of this report. In this derivation, the criteria was determined to be approximately 6 µR/h, above background, which correlates to 5 pCi/g, above background, of Ra-226.

Exhibit G, Exposure Rate Measurements at One Meter, supplies the summarized results of this analysis. In this exhibit, each survey unit is compared directly against the criteria. The comparison demonstrates that all survey units are substantially less than the allowable level. Figure VII-1, Survey Unit Exposure Data vs. Criteria, depicts the exposure rate data for each unit in comparison to the allowable criteria.

Statistical Tests

Data Acceptance

All exposure rate data was reviewed for completeness and accuracy and found to meet acceptance criteria. All soil data was reviewed and found to be acceptable. There was a discrepancy in location identification on soil sample 98RVS05; it was identified as coming from a coordinate that fell 250 feet north of where it should have been taken. However, this discrepancy had no impact on the overall survey evaluation.

Exposure Data Evaluation

The final exposure rate evaluation was performed using the Wilcoxan Rank Sum test, which can be reviewed in Appendix I, Wilcoxan Rank Sum Results. This test determines if the null hypothesis – that the residual contamination exceeds the acceptance criterion – should be rejected. To reject the null hypothesis, the evidence must be overwhelmingly (both type I and II errors are satisfied at the 95% confidence level) to the contrary – that the survey unit satisfies acceptance criteria.

The test involves comparing the ranked sum against a critical value. When the sum exceeds the critical value the null hypothesis is rejected. In each case involving a survey unit from the River Valley School District property, the null hypothesis was rejected, thus the alternative hypothesis, that the survey unit meets acceptance criteria, is accepted as the final evaluation. The results of these tests have been summarized into Tables VII-2, 3, and 4.

Soil Data Evaluation

All 50 systematic soil results were found to be substantially less than the 5 pCi/g, above background, criteria. A table of all soil results may be reviewed in Exhibit F, Final Soil Analysis Results. A comparison of soil results, against the criterion, is presented in Figure VII-2. A stucents-t test was also performed on the data. However, due the homogeneity of the data, the estimated average at the 95% confidence level was nearly identical to the actual average.

Conclusions

The radiological survey conducted at the River Valley School District property was designed to detect, at a minimum, Ra-226 contamination in the first 6" of soil over all accessible surfaces on the River Valley School District property. To this end, the investigation was successful and it can be asserted with a very high degree of confidence that no previously unidentified contamination exists on the River Valley School Property at levels approaching acceptance criterion.

Beyond this, it can be stated that, given the nature of the potential contaminant and the intensity of the survey, no significant level of contamination exists to a level of several feet below the surface.

This conclusion is supported by the evidence presented in this report. This evidence includes a 100% radiological scan of the property, both qualitative and statistical evaluations of soil and exposure data against acceptance criteria, and the evaluation of 41 investigative surveys. These evaluations were performed under the review of industry recognized experts in the field of radiation protection.

Lastly, it can be asserted, again with a very high level of confidence, that no increased health risk exists at the River Valley School District property due to Ra-226 surface contamination.

Figure VII-3 WILCOXON RANK SUM TEST RESULTS
Survey Units 001 - 057

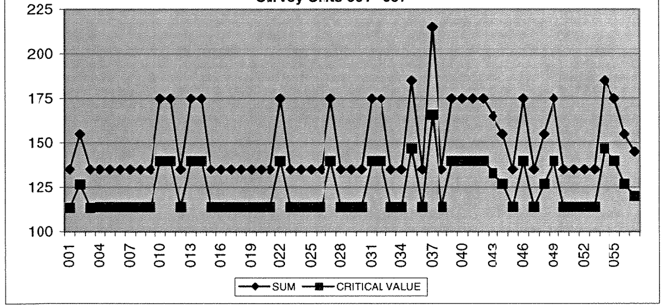


Figure VII-4 WILCOXON RANK SUM TEST RESULTS
Survey Units 058 - 114

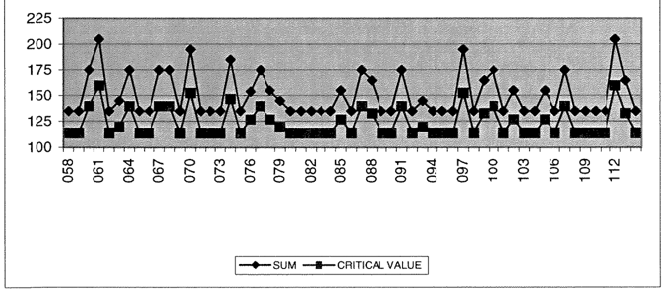
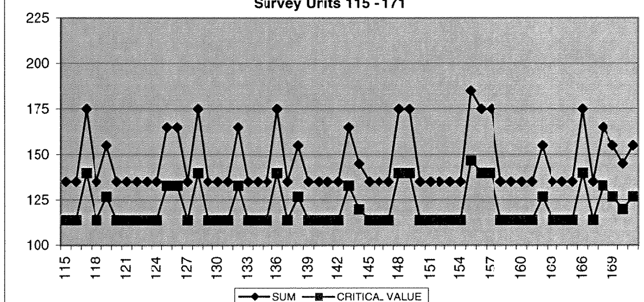


Figure VII-5 WILCOXON RANK SUM TEST RESULTS
Survey Units 115 - 171



Safety and Ecology Corporation

SEC

Exhibit A
PIC vs. NaI Correlation Development

Exhibit A

Exhibit A

PIC vs. NaI Development

A least squares, linear correlation was developed for the River Valley School site using data pairs from two different locations; the Marion Ohio Municipal Airport and the Luckey Ohio site located south of Toledo Ohio.

The Luckey Ohio site was chosen because no significant radium contamination was encountered at the River Valley School District site.

A single correlation was developed for the conversion of all 1-meter exposure rate data as measured with the NaI 2 inch by 2 inch detectors used at the River valley School District site The response characteristics of all instrumentation, at the relevant exposure rates, were essentially the same thus allowing the use of the single correlation. The correlation equation for determining cpm from µR/h is presented as Eq. A-1. The correlation equation for determining µR/h is presented as Eq. A-2.

$$cpm = 1471.8 * \mu R / h + (-5300) \qquad Eq.A-1$$

$$\mu R / h = (cpm + 5300) / 1471.8 \qquad Eq.A-2$$

PIC to [illegible] Correlation

Exhibit A

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.9867541
R Square	0.9736838
Adjusted R Sq	0.9692977
Standard Error	1588.0393
Observations	8

SN: 87809

Y = 1480.2x + (-5334.7)

	G023	87809
	PIC (x)	cpm (y)
*	127.3	174235
	21.1	24279
	24.1	31938
	11.5	12347
	10.1	10357
	8.2	7775
	7.8	6936
	12.6	*12950*
	10.5	7494

ANOVA

	df	SS	MS	F	ignificance F
Regression	1	559844865	6E+08	222	5.7525E-06
Residual	6	15131213	3E+06		
Total	7	574976078			

	Coefficients	tandard Erro	t Stat	P-value	Lower 95%	pper 95	ower 95.0	Upper 95.0%
Intercept	-5334.741	1429.92943	-3.731	0.0097	-8833.6544	-1835.83	-8833.6544	-1835.82674
X Variable 1	1480.207	99.3458799	14.9	6E-06	1237.11624	1723.298	1237.1162	1723.29782

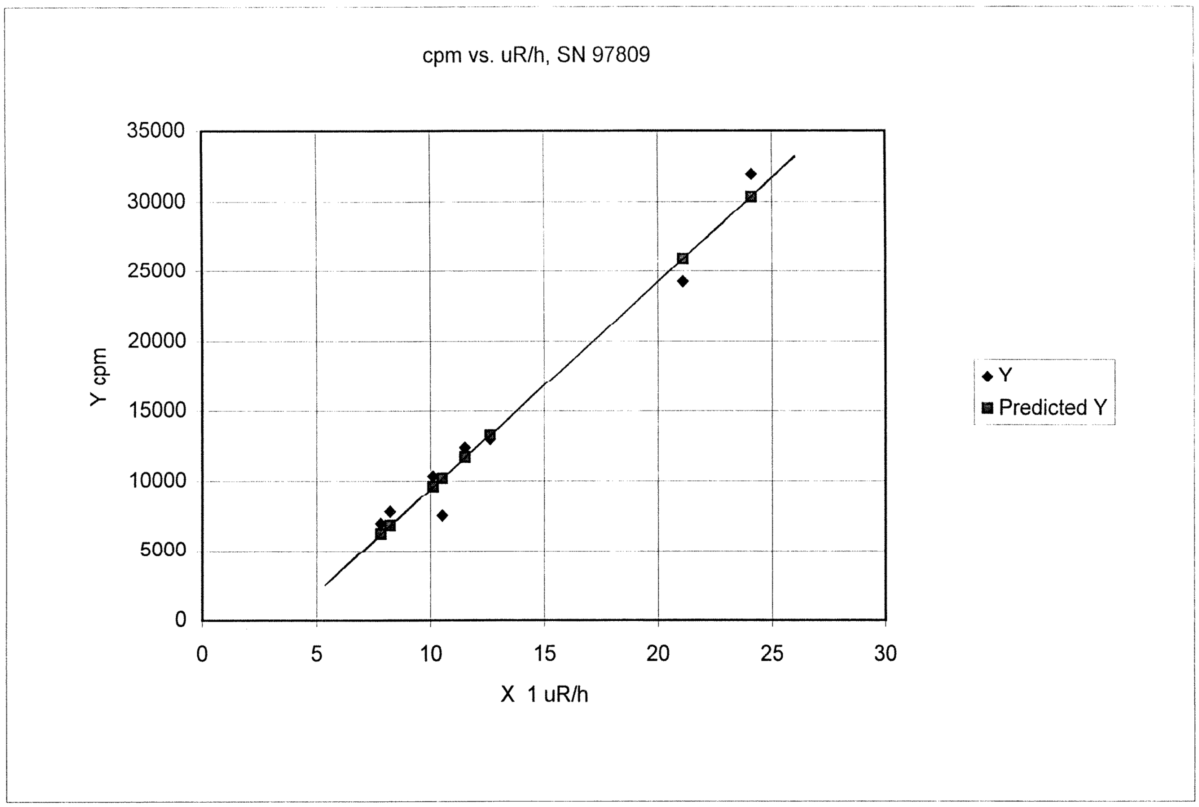
RESIDUAL OUTPUT

Observation	Predicted Y	Residuals
1	25897.628	-1618.62777
2	30338.249	1599.75114
3	11687.64	659.359714
4	9615.3504	741.649556
5	6802.9571	972.042913
6	6210.8743	725.125725
7	13315.868	-365.868018
8	10207.433	-2713.43326

* Note included in correlation analysis because the reading was considered to be to far above relevant range.

PIC to . Correlation

Exhibit A



PIC to [illegible] Correlations

Exhibit A

SUMMARY OUTPUT

SN: 103977
Y = 1463.4x + (-5266.7)

G023 PIC (x)	103977 cpm (y)
* 127.3	173622
21.1	22983
24.1	32297
11.5	12094
10.1	10117
8.2	7647
7.8	6905
12.6	13410
10.5	7389

Regression Statistics	
Multiple R	0.980801
R Square	0.961971
Adjusted R Squ	0.955633
Standard Error	1898.807
Observations	8

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	547216642	5.47E+08	151.774	1.74377E-05
Residual	6	21632815.6	3605469		
Total	7	568849458			

	Coefficient	*tandard Erro*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0*	*pper 95.0%*
Intercept	-5266.74	1709.75647	-3.080404	0.021652	-9450.366339	-1083.1135	-9450.366	-1083.113
X Variable 1	1463.418	118.787164	12.31966	1.74E-05	1172.755627	1754.0795	1172.756	1754.079

RESIDUAL OUTPUT

Observation	*redicted*	*Residuals*
1	25611.37	-2628.37055
2	30001.62	2295.37678
3	11562.56	531.438006
4	9513.777	603.222586
5	6733.284	913.715946
6	6147.917	757.082968
7	13172.32	237.678693
8	10099.14	-2710.14444

PROBABILITY OUTPUT

Percentile	*Y*
6.25	6905
18.75	7389
31.25	7647
43.75	10117
56.25	12094
68.75	13410
81.25	22983
93.75	32297

* Note included in correlation. Considered to be to far above relevant range.

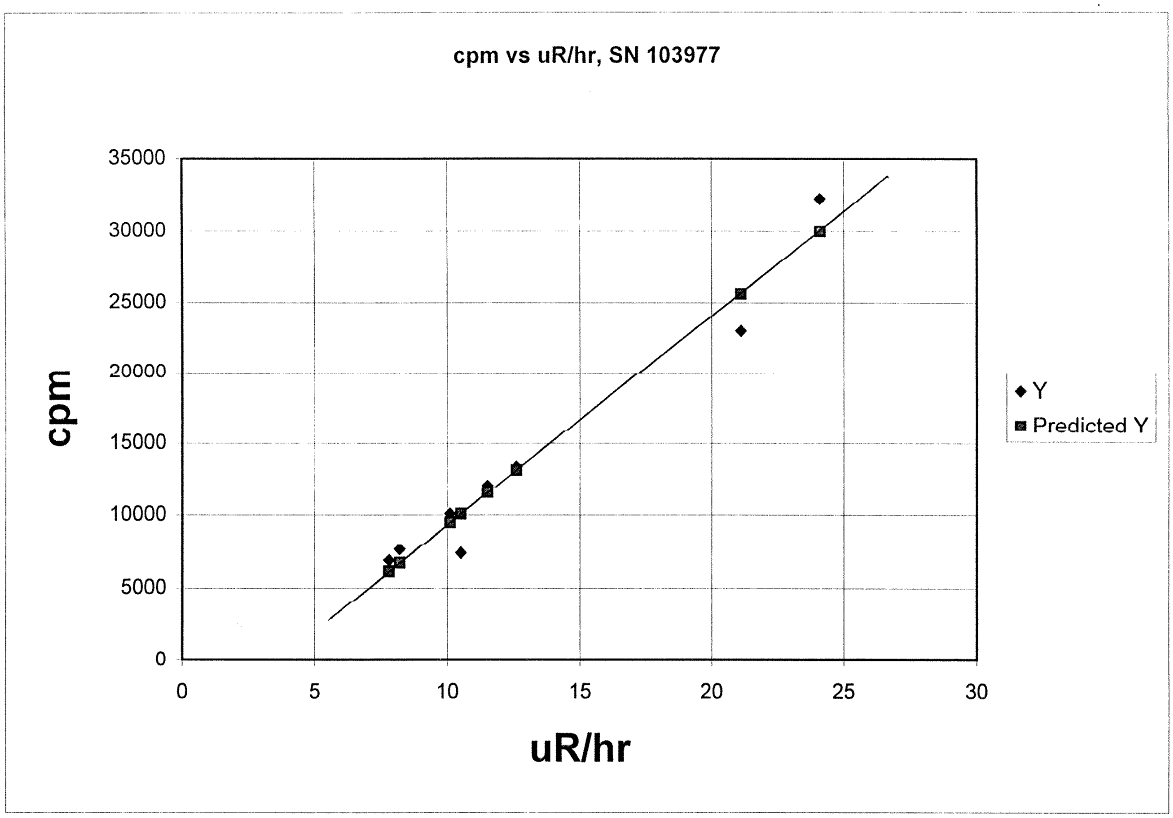

cpm vs uR/hr, SN 103977
cpm
35000
30000
25000
20000
15000
10000
5000
0
0
5
10
15
20
25
30
uR/hr
Y
Predicted Y

Exhibit B
Minimum Detectable Count Rate Estimate

Exhibit B

Exhibit B

Minimum Detectable Count Rate Estimate

This derivation follows the guidance of NUREG-1507 which was issued in December of 1997. The following discussion is taken directly from the text.

"6.8.2 Scan MDCs for Land Areas

... The NaI scintillation detector background level and scan rate (observation interval) are postulated, and the MDCR for the ideal observer, for a given level of performance, is obtained. a surveyor efficiency is selected, and then it is necessary to relate the surveyor MDCR ($MDCR_{surveyor}$) to a radionuclide concentration in soil (in pCi/g). This correlation requires two steps – first, the relationship between the detector's net count rate to net exposure rate (cpm/μR/h) is established; and second, the relation ship between the radionuclide contamination and exposure rate is determined for a particular gamma energy...."

The first step, described above is determined in Exhibit A, PIC vs. NaI Correlation Development. The second step was performed using an exposure modeling program called "Microshield" and can be reviewed in appendix C, Operation Guidelines for Source and Contaminated Soil Determinations at the River Valley Site in Marion, Ohio; June 1998.

For this determination, a background level for the Marion of 10,000 cpm has been selected. The scan rate is 0.5 to 1.0 meters per second (from the Marion work plan, section 13.3), the following calculation will use a scan rate of 0.75 m/s. The surveyor efficiency is selected to be 0.5 (NUREG-1507, section 6.7.2).

The background counts (bi) detected in the observation interval is calculated in equation B-1.

$$b_i = R_b * t_s * \min/s \qquad \text{B-1}$$

The mimimum detectable count rate (MDCR) is calculated in equation B-2.

$$MDCR = d' * \sqrt{b_i} * s/\min \qquad \text{B-2}$$

The minimum detectable count rate for a surveyor ($MDCR_{surveyor}$) is calculated in equation B-3.

$$MDCR_{surveyor} = \frac{MDCR}{\sqrt{p}} \qquad \text{B-3}$$

Where:
- b_i = counts in observation interval.
- R_b = Rate of background in cpm.
- T_s = Time of detector over the selected observation.
- Min. = Minute
- s = Seconds
- d' = index of detectability
- p = detection ability of the observer

Selected, or Calculated Marion, Ohio criteria

Where:
- b_i = 66.7 c/s = (0.75m/s)*(0.5 m)*(10,000).
- R_b = 10,000 = actual observed background rate for Marion, Ohio.
- T_s = 0.4 s = (0.75 m/s)*(0.5 m).
- Min. = 60 seconds.
- s = 1/60 minutes.

Exhibit B

Minimum Detectable Count Rate Estimate

d' = 1.64, from NUREG-1507, Table 6-1, False Positive rate of 0.5, True positive rate of 0.95.

p = 0.5, from NUREG-1507, section 6.7.2.

The MDCR and MDCR can be calculated by combining equations B-2, and B-3, and substituting in the selected or derived Marion, Ohio parameters.

$$MDCR_{surveyor} = \frac{1.64 * \sqrt{66.7} * 60}{\sqrt{0.5}} = 1136.2\ cpm$$

By using the PIC vs. NaI correlation equation, this calculated detectable count rate can now be converted into terms of μR/h above background which can be detected 95% of the time over an area of $0.5 m^2$.

From exhibit A, the cpm/μR/h rate has been calculated to be 1471.8 cpm/μR/h. Substituting the $MDCR_{surveyor}$ rate into this equation yields the following:

$$MDCR_{surveyor,\mu R/h} = 1136.2\ \text{cpm} * \frac{1 \mu R/h}{1471.8\ \text{cpm}} = 0.8\ \mu\text{R/h}$$

Exhibit C
Determination of Data Point Requirements

Exhibit C

Exhibit C

Determination of Data Point Requirements

To calculate the number of exposure rate measurements required to satisfy the statistical requirements of MASSIM was calculated following the steps outlined below.

1) Calculate the Relative Shift (Δ/σ)

$$\Delta = DCGL_W - LBGR$$

a. Determine the DCGLw

SEC selected a derived guideline (DCGL) of 6 μR/h, above background, at 3.3 ft above the surface, to be equivalent to a soil concentration of 5 pCi/g – the default criterion of the State of Ohio (Part III and Appendix III provide an explanation of how this was determined).

b. Determine the LBGR

The Lower Bound of the Gray Region was selected to be 0 μR/h above background.

Sigma should be produced empirically from both the reference area (σ_r) and the survey area (σ_s). However, this data was not available as this project started. SEC estimated the average background exposure rate 7.0 +/- 2.0 μR/h (1 σ), based on survey results of the State of Ohio.

SEC estimated that the standard deviation in the background area would be indistinguishable from the survey area. Therefore:

$\sigma_r = \sigma_s = 2.0$

c. The relative shift was calculated to be:

Δ = 6 - 0
= 6
σ_{rs} =2
Δ/σ =3

MARSSIM recommends a range of 1 to 3 for Δ/σ and the value calculated here is within that range.

2) Determine Pr

This is taken directly from MARSSIM (page 5-28, Table 5.1). The P_r is 0.983039.

Exhibit C

Determination of Data Point Requirements

3) Determine the Decision Error Percentiles

The null hypothesis (H_o) for each survey unit is that the residual radioactivity exceeds the $DCGL_W$.

Acceptance decision errors for testing the hypothesis are set at 0.05 for both Type I and Type II errors.

4) Obtain the Number of Data Points

$$N = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{3(P_r - 0.5)^2}$$

$$N = \frac{1.654 + 1.645)^2}{3(0.983 - 0.5)^2} = 15.5$$

Adding an additional 20% to allow for potential sample loss and QC gives 18.6. This is rounded up to 20. The data points are split evenly between the reference area and the survey area to yield 10 data points per survey unit.

5) Data Point Needs for Areas of Elevated Activity

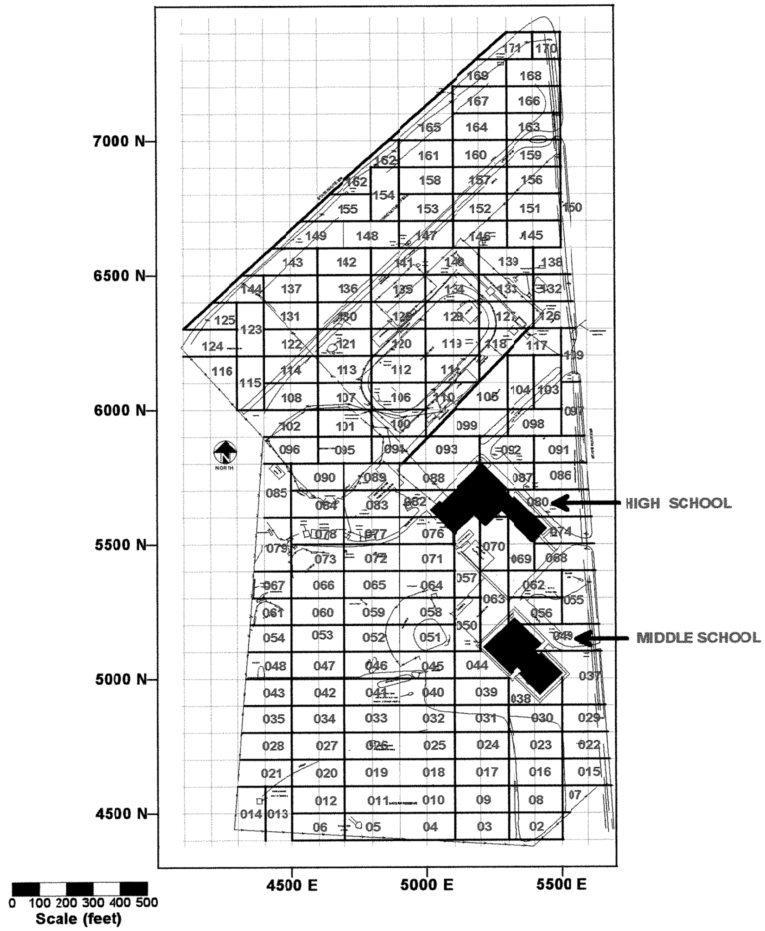
Sensitivities of proposed instruments and techniques are such that $DCGL_W$ concentrations can be identified by scans; additional data are not needed for identifying areas of elevated activity.

Safety and Ecology Corporation

SEC

Exhibit D
Scan and Investigation Results

Exhibit D



RIVER VALLEY SCHOOL - RADIOLOGICAL INVESTIGATION - SURVEY UNITS

SAFETY AND ECOLOGY CORPORATION KNOXVILLE, TENNESSEE	U. S. ARMY CORPS OF ENGINEERS LOUISVILLE DISTRICT
DRAWN BY: LAWHON & ASSOCIATES, Inc. WESTERVILLE, OHIO	MONTGOMERY WATSON DETROIT, MICHIGAN

Scan Survey Summary

Exhibit D

River Valley School District

Survey Unit	Surface	uR/h	Average Rate (kcpm)	Max Rate (kcpm)	Investigate	Sub-Unit (Grid ID)	Result/Comments
1	Brick	12.5	13.2	14.3	No	NA	Back side and east wing of middle school.
2	Wilderness area	11.5	11.7	13	No	NA	
3	Wilderness area	10.9	10.8	12.5	No	NA	A count taken down a groundhog hole produced counts of 25 kcpm. This is consistent with down hole background gamma rates (see Appendix III, part 3.)
4	Wilderness area	10.9	10.8	11.8	No	NA	
5	Wilderness area	10.7	10.5	11.5	No	NA	
6	Wilderness area	10.7	10.5	11.5	No	NA	
7	Grass	11.3	11.4	12	No	NA	
8	Grass	11.4	11.5	12.1	No	NA	
9	Grass	10.9	10.8	12.6	No	NA	
10	Wilderness area	10.8	10.7	12.6	No	NA	
11	Wilderness area	10.8	10.7	11.8	No	NA	
12	Wilderness area	10.5	10.2	11.3	No	NA	
13	Wilderness area	11.1	11.1	11.6	No	NA	
14	Wilderness area	10.9	10.8	12.5	No	NA	
15	Grass	10.8	10.7	11.7	No	NA	
16	Wilderness area	11.5	11.7	12.6	No	NA	
17	Wilderness area	10.7	10.5	12.6	No	NA	
18	Wilderness area	10.8	10.7	12.8	No	NA	
19	Wilderness area	10.6	10.4	12.2	No	NA	
20	Wilderness area	10.6	10.4	11.4	No	NA	
21	Wilderness area	10.7	10.5	11.7	No	NA	
22	Grass	10.9	10.8	12	No	NA	
23	Wilderness area	11.5	11.7	13.1	No	NA	
24	Wilderness area	10.2	9.8	12.7	No	NA	
25	Wilderness area	10.5	10.2	12.5	No	NA	
26	Wilderness area	10.6	10.4	12	No	NA	
27	Wilderness area	10.6	10.4	13	No	NA	
28	Wilderness area	10.8	10.7	11.8	No	NA	
29	Grass	11.2	11.3	12.8	No	NA	
30	Grass, Wilderness	11.9	12.3	13.4	No	NA	
31	Wilderness area	11.7	12.0	12.4	No	NA	
32	Wilderness area	10.6	10.4	13.7	No	NA	

Survey Unit	Surface	uR/h	Average Rate (kcpm)	Max Rate (kcpm)	Investigate	Sub-Unit (Grid ID)	Result/Comments
33	Wilderness area	10.6	10.4	11.9	No	NA	
34	Wilderness area	10.5	10.2	12.2	No	NA	
35	Wilderness area	10.7	10.5	14.4	Yes	B-5	Elevated measurement taken at bottom of 1foot deep rut. Increased rate likely due to geometry change. Soil Sample 98RVS054 taken at this sample spot resulted in a radium concentration of 1.7 pCi/g.
36	Brick	13.3	14.4	16.5	No	NA	Front and east wing of middle school.
37	Grass	10.7	10.5	12.5	No	NA	
38	Grass	12.2	12.7	12.5	No	NA	
39	Grass Field	11.8	12.1	12.4	No	NA	
40	Wilderness area	10.7	10.5	13.9	Yes	A-8	The scanning technician was unable to reproduce the elevated count. The highest count rate found was 12.2 kcpm.
41	Wilderness area	10.5	10.2	11.9	No	NA	
42	Wilderness area	10.3	9.9	11.8	No	NA	
43	Wilderness area	10.8	10.7	16.3	Yes	C-2	The highest count rate was found on contact with old rail road ballast material (cinders and rock ballast). Soil Sample 98RVS055 was taken at this point. The results (in pCi/g) for Ra-226 and U-238 were 2.49, and 12.9 respectively. The results are typical of hard rock analysis - uranium criteria is typically around 35 pCi/g or higher.
						D-4	There was a dirt pile in this grid. Slightly higher count rates are likely due to geometric effects.
						C-6	An elevated reading was taken on contact with a brick which was located on a dirt pile. Ambient levels were around 12 kcpm.
						C-7	Contact reading taken on a brick located on the dirt pile.
						C-8	Contact reading taken on a brick located on the dirt pile.
44	Grass Area	11.7	12.0	11.6	No	NA	
45	Grass, some gravel	11.5	11.7	14.5	No	NA	
46	Grass Field	11.4	11.5	13.8	No	NA	
47	Grass Field	10.4	10.1	12.3	No	NA	
48	Grass Field	10.7	10.5	40	Yes	A-2	This reading was taken on, or near, a piezometer. At the time of the original survey (6/20/98) it was surmised that the increased count rate was due to soil venting of radon (especially up through the pizometer). The follow-up investigation occurred on 7/15/98. No elevated count rates were found. This is believed to be due to heavy rain fall in the Marion area which effectively trapped soil gasses.
						C-3	See note be A-2.
						D-2	See note be A-2.

Scan Survey Summary — **Exhibit D** — **River Valley School District**

Survey Unit	Surface	uR/h	Average Rate (kcpm)	Max Rate (kcpm)	Investigate	Sub-Unit (Grid ID)	Result/Comments
49	Grass and Asphalt	9.7	9.0	11.6	No	NA	
50	Asphalt, grass, gravel	9.4	8.6	12.2	No	NA	
51	Grass, dirt, gravel	10.5	10.2	11.5	Yes	A-8	Contact readings varied from 6.3 to 11.6 kcpm in this grid. The variation is due to a transition between grass and gravel.
						B-8	Contact readings varied from 7.1 to 10.3 kcpm in this grid. The variation is due to a transition between grass and gravel.
						C-8	Contact readings varied from 7.1 to 10.9 kcpm in this grid. The variation is due to a transition between grass and gravel.
						D-8	Contact readings varied from 6.4 to 11.2 kcpm in this grid. The variation is due to a transition between grass and gravel.
52	Grass Field	11.4	11.5	13.1	No	NA	
53	Grass Field	10.3	9.9	13	Yes	B-7	Reading taken in crack in soil. Elevated counts attributable to geometric effects.
54	Grass and Dirt	10.6	10.4	16.3	Yes	C-2	Contact readings on old rail road bed. See comment for unit number 43.
						D-2	See comment above.
						C-5	See comment above.
55	Grass	10.6	10.4	11.7	No	NA	
56	Asphalt and Grass	10.3	9.9	10.8	No	NA	
57	Grass, Concrete, Asphalt.	9.6	8.9	11.7	No	NA	
58	Grass, Dirt, Gravel.	11	11.0	14.7	--	--	The 14.7 kcpm count was taken on contact with a brick located in a shed.
59	Grass	11.3	11.4	13.2	No	NA	
60	Grass	10.4	10.1	13.2	Yes	D-4	An area approximately 6x8 feet was identified on 6/10/08 as having non uniform count rates. However, during the investigative survey on 7/14/98, the technicians were unable to duplicate the non-uniformity.
61	Ball field, dirt, grass.	10.3	9.9	16.9	Yes	A-3	Contact on surface of old railroad bed. See comment for unit 43.
						B-3	See comment above.
						D-3	See comment above. .
62	Grass, Asphalt	11	11.0	11.1	No	NA	
63	Asphalt, grass	9	8.0	10.7	No	NA	
64	Grass Field	10.8	10.7	11.4	No	NA	
65	Grass Field	11.4	11.5	12.8	No	NA	

Scan Survey Summary **Exhibit D** **River Valley School District**

Survey Unit	Surface	uR/h	Average Rate (kcpm)	Max Rate (kcpm)	Investigate	Sub-Unit (Grid ID)	Result/Comments
66	Grass	10.5	10.2	12.8	No	NA	
67	Grass Field	11.1	11.1	16.5	Yes	A-3	Taken on contact with railroad ballast.
						B-3	Taken on contact with railroad ballast. A sample was taken of this material. Sample results for this sample (98RVS056) for Ra-226 and U-238 were 2.18 and 3.11 pCi/g respectively.
68	Grass, Asphalt, Concrete	10.9	10.8	12.2	No	NA	
69	Grass	11.3	11.4	12.5	No	NA	
70	Grass	11.1	11.1	12.2	No	NA	
71	Grass Field	11.5	11.7	12.8	No	NA	
72	Grass Field	11.5	11.7	14	Yes	D-5	This was a straight line anomaly commonly associated with bedding material found around utility runs. The highest gamma reading along this line was chosen to be sampled (98RVS057). The sample was taken from a composite of soil ranging from 0 to 18 inches below the surface. The results for this sample for Ra-226 and U-238 were 1.46 and 3.25 pCi/g respectively
						D-6	Same comment as above.
73	Ball field, grass, gravel road	10.2	9.8	12.4	Yes	D-8	The technicians were unable to duplicate evidence of a gamma anomoly.
74	Grass, Asphalt, Concrete	10.7	10.5	11.4	No	NA	
75	Brick	12	12.4	15	No	NA	South part of high school.
76	Grass, gravel, Concrete	11.3	11.4	12.7	No	NA	
77	Grass, Gravel Rd., Concrete block Bld.	11	11.0	15	Yes	B-4	Dirt floor to gravel transition in building.
						A-1	Grass to gravel road transition.
						A-8	Technicians unable to duplicate original investigative results.
						A-7	Gravel to grass transition.

Scan Survey Summary **Exhibit D** **River Valley School District**

Survey Unit	Surface	uR/h	Average Rate (kcpm)	Max Rate (kcpm)	Investigate	Sub-Unit (Grid ID)	Result/Comments
78	Grass, Gravel Rd., Dirt in part of bld.	10.6	10.4	22.5	Yes	A-1	Grass to gravel road transition.
						D-4	Gravel to grass transition.
						C-4	Grass/gravel/dirt transitions.
						D-5	Gravel to grass transition.
						C-5	Gravel to grass to dirt transitions. Technicians unable to duplicate the 22.5 kcpm count indicated on initial scan investigation.
79	Grass/over-growth	10.4	10.1	12.8	No	NA	
80	Grass, asphalt road.	10.4	10.1	11.5	No	NA	
81	Brick	12.1	12.6	16.1	No	NA	
82	Grass, gravel, asphalt.	9.3	8.4	11.8	No	NA	
83	Grass, Concrete, Gravel	11.4	11.5	12.6	No	NA	
84	Ball field, grass, gravel road	10.8	10.7	11.8	No	NA	
85	Grass, Concrete	10.6	10.4	11.8	Yes	C-8	Concrete to grass transition.
						B-7	Concrete to grass transition
						C-7	Concrete to grass transition.
86	Grass	10.9	10.8	10.8	No	NA	
87	Asphalt, grass	9.9	9.3	11	No	NA	
88	Asphalt, Gravel	8.7	7.6	8.9	No	NA	
89	Ball field, grass, Dirt, asphalt, gravel	10.3	9.9	11.6	No	NA	
90	Ball field, grass, gravel.	10.4	10.1	11.4	No	NA	
91	Grass	11.1	11.1	25.5	Yes	D-6	25.7 kcpm contact reading. This was believed to be the spot from which the source was removed in 1997. Soil sample 98RVS058 was taken at the highest reading point - Ra-226 and U-238 results were 42.4 and 3.02 pCi/g respectively. These results appear to confirm the stated belief. It should be noted that the detail drawing from this area indicates that count rates drop to background levels within 5 feet of the residual contamination spot.
92	Asphalt, grass	9.5	8.7	10.5	No	NA	
93	Asphalt	8.2	6.8	8	No	NA	

Scan Survey Summary

Exhibit D

River Valley School District

Survey Unit	Surface	uR/h	Average Rate (kcpm)	Max Rate (kcpm)	Investigate	Sub-Unit (Grid ID)	Result/Comments
94	Grass, Asphalt	11.3	11.4	11.8	No	NA	
95	Grass	10.5	10.2	11.6	No	NA	
96	Ball field, Grass, dirt.	10.5	10.2	11.8	No	NA	
97	Grass	10.2	9.8	12.9	No	NA	
98	Grass, asphalt	10.8	10.7	11.2	No	NA	
99	Asphalt, grass	8.7	7.6	10.2	No	NA	
100	Grass, asphalt track, gravel	9.8	9.2	12.5	Yes	C-6	Track to grass transition.
						C-7	Track to grass transition.
101	Grass	10.8	10.7	11.9	No	NA	
102	Grass, gravel	10.2	9.8	11.1	No	NA	
103	Asphalt, grass	9.3	8.4	10.5	No	NA	
104	Asphalt, grass	8.4	7.1	9.7	No	NA	
105	Asphalt	8.6	7.4	7.8	No	NA	
106	Grass, Running track, red cinders	9.9	9.3	14.7	Yes	A-1	Asphalt track to grass transition.
						A-2	Asphalt track to grass transition.
						B-1	Asphalt track to grass transition.
						B-2	15 kcpm taken on/around a brick bell stand. Elevated counts attributable to geometrical effects and surface materials.
107	Grass, running track	10.5	10.2	12.7	Yes	A-8	Asphalt track to grass transition.
108	Grass, asphalt	10.1	9.6	12.8	No	NA	
109	Grass, Asphalt, Gravel	9.4	8.6	10.5	No	NA	
110	Asphalt track, grass, gravel	9.4	8.6	11.4	No	NA	
110	Grass, Asphalt, gravel	9.4	8.6	10.2	No	NA	
111	Grass, Asphalt	9.8	9.2	10.3	No	NA	
112	Grass, Asphalt track.	10	9.5	10.3	No	NA	
113	Grass, gravel, running track	10.4	10.1	12.5	No	NA	
114	Grass, Asphalt rd.	10.1	9.6	11.6	Yes	A-4	Asphalt to grass transition.
						B-3	Asphalt to Ag. Field Transition
						D-5	Asphalt to Ag. Field Transition
						D-7	Asphalt to grass transition.
115	Grass, gravel, Asphalt	9.9	9.3	11.7	No	NA	

Scan Survey Summary **Exhibit D** **River Valley School District**

Survey Unit	Surface	uR/h	Average Rate (kcpm)	Max Rate (kcpm)	Investigate	Sub-Unit (Grid ID)	Result/Comments
116	Grass	10.5	10.2	11.3	No	NA	
117	Grass, asphalt	9.9	9.3	11	No	NA	
118	Grass, Gravel	10.8	10.7	12.9	No	NA	
119	Grass, Asphalt, Gravel	10.1	9.6	11.1	No	NA	
120	Bleachers - concrete, gravel, grass, track	9.5	8.7	10.9	No	NA	
121	Grass, Asphalt, Gravel	9.9	9.3	12.2	Yes	A-8	Gravel to grass transition.
						D-4	Gravel to grass transition.
						D-3	Asphalt to grass transition.
						D-1	Asphalt to grass transition.
122	Ag. Field, Grass, Asphalt	10.3	9.9	13.7	Yes	A-6	Asphalt to grass transition.
						A-8	Asphalt to gravel to grass transition.
						B-7	Ag. Field to asphalt transition.
123	Grass	10.5	10.2	11.1	No	NA	
124	Grass	10.5	10.2	11.1	No	NA	
125	Grass	10.2	9.8	12.1	No	NA	
126	Grass, Gravel	10.9	10.8	11.6	No	NA	
127	Grass, Asphalt, Sand	10.3	9.9	13.6	No	NA	
128	Grass, Asphalt	9.7	9.0	11.9	No	NA	
129	Tennis court - asphalt, Bleacher - concrete, gravel, concrete.	8.9	7.9	11	No	NA	
130	Ag. Field, Asphalt, gravel, grass	10.1	9.6	12.2	Yes	A-2	Asphalt to Ag. Field Transition
						B-2	Ag. Field to asphalt transition.
						D-6	Ag. Field to asphalt transition.
131	Ag. Field, Grass	10.5	10.2	12.3	No	NA	
132	Grass, Gravel Pit	10.6	10.4	11.1	No	NA	

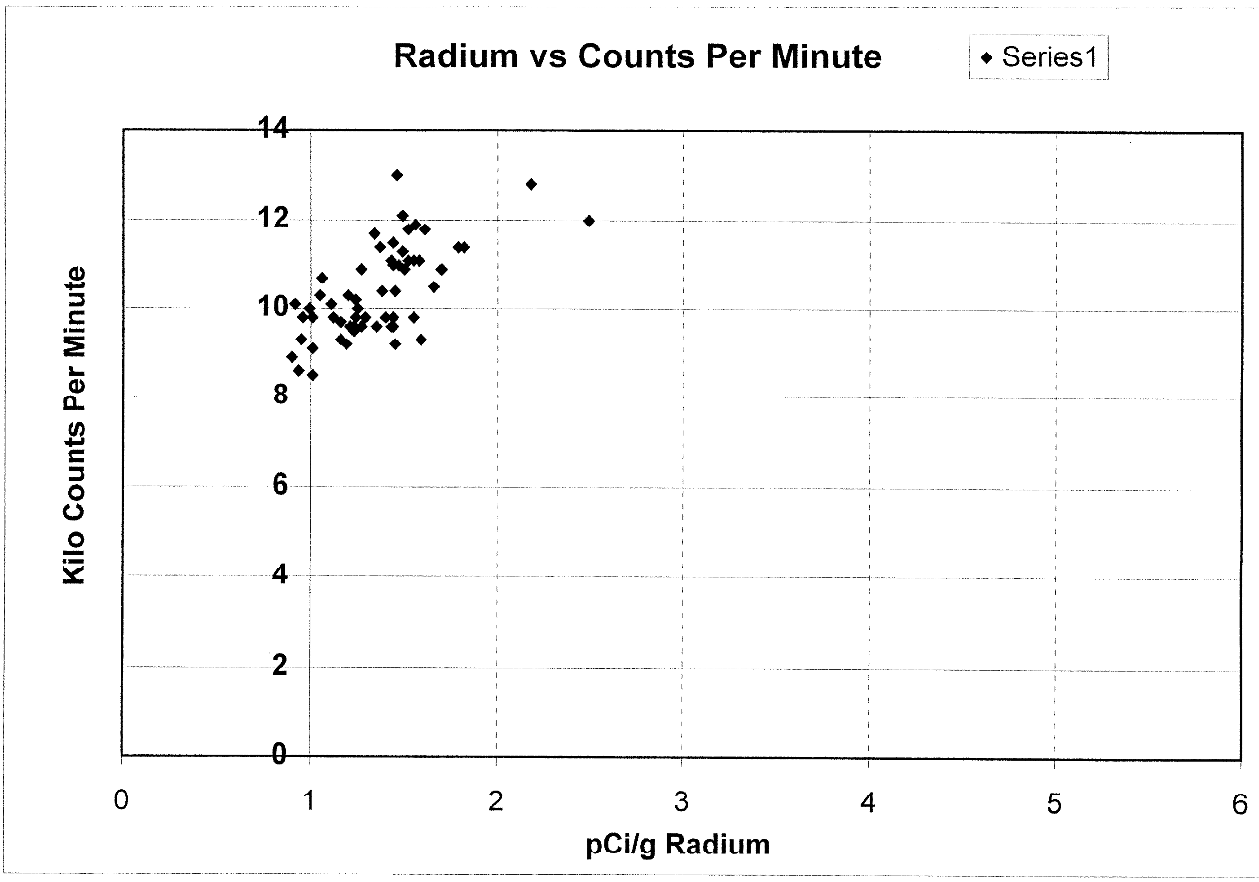
Scan Survey Summary | **Exhibit D** | **River Valley School District**

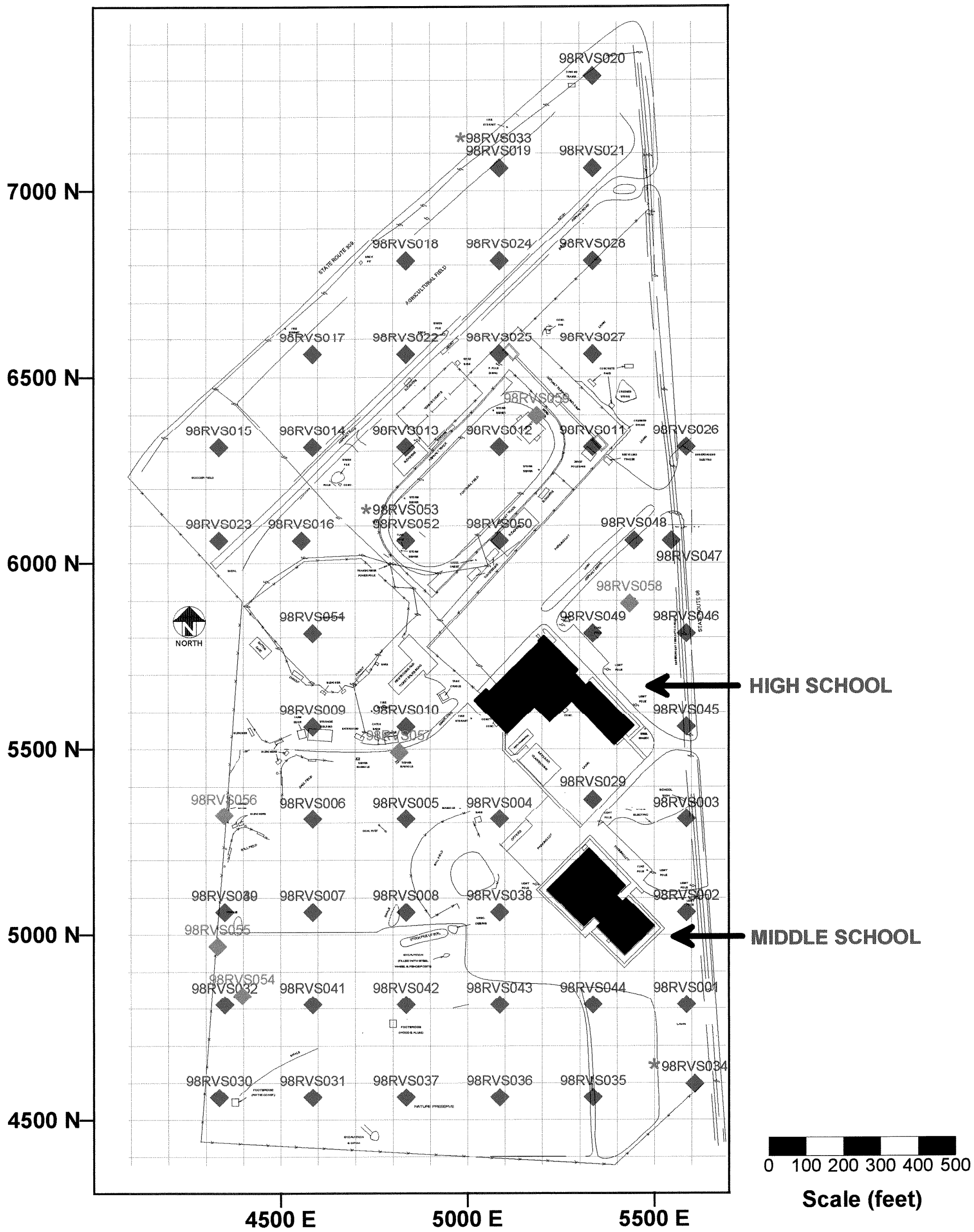
Survey Unit	Surface	uR/h	Average Rate (kcpm)	Max Rate (kcpm)	Investigate	Sub-Unit (Grid ID)	Result/Comments
133	Grass, Asphalt, Gravel.	10.9	10.8	11.5	No	NA	
134	Grass, Asphalt, concrete, tennis court	9.3	8.4	13.5	Yes	A-8	A soil sample (98RVS059) was taken at the edge of the track were a contact gamma reading or 14 kcpm was found. The results for Ra-226 and U-238 were 1.66 and 1.27 pCi/g respectively.
135	Tennis court, grass, road asphalt	8.9	7.9	9.8	No	NA	
136	Ag. Field, Asphalt.	9.8	9.2	12.5	Yes	B-8	Asphalt to grass transition. A 25 kcpm measurement was taken down a gopher hole - this is consistent with background, subsurface gamma rates.
137	Ag. Field, Grass	10.4	10.1	12.3	No	NA	
138	Grass, Concrete	9.5	8.7	11.1	No	NA	
139	Grass, Concrete	10.1	9.6	12.2	No	NA	
140	Grass, Asphalt	10	9.5	11.8	No	NA	
141	Tennis court, asphalt, Ag. Field, Grass, gravel	9.8	9.2	11.1	No	NA	
142	Ag. Field, Grass	10.2	9.8	11.3	No	NA	
143	Ag. Field, Grass	10.3	9.9	11.5	No	NA	
144	Grass	10.2	9.8	11.4	No	NA	
145	Grass	9.7	9.0	12.7	No	NA	
146	Grass, Concrete	9.8	9.2	1.9	No	NA	
147	Ag. Field, grass, gravel, asphalt rd.	9.4	8.6	11.2	Yes	A-2	Ag. Field to asphalt transition.
						A-5	Asphalt to grass transition.
						D-8	Asphalt to grass transition.
						B-4	Ag. Field to asphalt transition.
148	Ag. Field, grass.	10.4	10.1	11.3	No	NA	
149	Ag. Field, grass	10.2	9.8	11.6	No	NA	
150	Grass, borrow area	10	9.5	10.5	No	NA	
151	Grass	9.6	8.9	12.5	No	NA	
152	Grass, asphalt, gravel	9.6	8.9	11.9	Yes	B-2	Gravel to grass transition.
						D-2	Asphalt to grass transition.
153	Ag. Field, Asphalt rd, gravel path, grass	9.9	9.3	10.6	No	NA	
154	Grass, Ag. Field	9.8	9.2	10.5	No	NA	

Survey Unit	Surface	uR/h	Average Rate (kcpm)	Max Rate (kcpm)	Investigate	Sub-Unit (Grid ID)	Result/Comments
155	Ag. Field, grass	10.1	9.6	11.4	Yes	D-4	A 20 kcpm measurement was taken down a gopher hole. This count rate is consistent with background count rates taken subsurface.
156	Grass	9.7	9.0	11.8	No	NA	
157	Ag. Field, Asphalt rd, gravel path, grass	9.7	9.0	12.4	Yes	A-3	Ag. Field to asphalt transition.
158	Ag. Field, grass	9.8	9.2	11	No	NA	
159	Ag. Field grass, Asphalt, gravel	9.2	8.3	11.6	No	NA	
160	Ag. Field, Asphalt rd, gravel path, grass	9.7	9.0	11.2	No	NA	
161	Ag. Field, Grass	9.7	9.0	10.8	No	NA	
162	Grass	9.8	9.2	11.2	Yes	A-1	A detail drawing of a brick lined drain located in this grid had count rates ranging from 22 to 12 kcpm. The 22 kcpm measurement was taken on the surface of the drain bottom. This is consistent with measurements taken in a subsurface geometry.
163	Ag. Field, Asphalt, Grass	10	9.5	11.5	Yes	A-3	Ag. Field to asphalt transition.
						A-4	Asphalt to grass transition.
						A-7	Technicians could not duplicate the variation in count rate encountered during the initial survey.
						A-8	Asphalt to grass transition.
						C-6	Asphalt to Ag. Field Transition
						C-7	Asphalt to Ag. Field Transition
						C-8	Ag. Field to asphalt transition.
164	Ag. Field,	9.7	9.0	11.5	Yes	A-3	A 13.2 kcpm measurement was taken down a ground hog hole. This consistent with the background ground-hog measurements taken off-site.
165	Ag. Field, Grass	10	9.5	11.2	No	NA	
166	Ag. Field, Grass	10	9.5	11.3	No	NA	
167	Ag. Field, grass	9.4	8.6	11.6	No	NA	
168	Ag. Field, grass, ditch.	9.5	8.7	20.5	Yes	C-6	A large rock (approximate 2x3 feet) was discovered approximately 2" below the surface. Contact readings on this rock yielded a count rate of 25.6 kcpm. This is consistent with expected hard rock materials.
169	Grass field	9.7	9.0	12.2	Yes	C-4	Highway to grass transition.
170	Grass	10	9.5	10.8	No	NA	
171	Grass, Ag. Field	9.8	9.2	11.2	No	NA	

Exhibit E
Radium vs. Counts Per Minute

Exhibit E


Radium vs Counts Per Minute
Series1
Kilo Counts Per Minute
pCi/g Radium
0
2
4
6
8
10
12
14
0
1
2
3
4
5
6



DRAWING NOTES:

* Indicates duplicate QC Sample

-98RVS54 was collected from the bottom of a one foot deep rut, survey unit 35.

-98RVS55 was collected from a ballast of an abandon rail road line, survey unit 43.

-98RVS56 was collected from a ballast of a abandon rail road line, survey unit 67.

-98RVS57 was collected from the highest gamma measurement along the straight line anomaly, survey unit 72.

-98RVS58 was collected from residual contamination from source removal area, survey unit 91.

-98RVS59 was was sampled from material at the edge of the running track, survey unit 134.

SAFETY AND ECOLOGY CORPORATION KNOXVILLE, TENNESSEE	SAMPLE LOCATIONS AT THE RIVER VALLEY SCHOOL DISTRICT MARION, OHIO	U. S. ARMY CORPS OF ENGINEERS LOUISVILLE DISTRICT
DRAWN BY: LAWHON & ASSOCIATES, Inc. WESTERVILLE, OHIO		MONTGOMERY WATSON DETROIT, MICHIGAN

Exhibit F
Final Soil Analysis

Exhibit F

Exhibit F Final Soil Analysis Results

		Location (ft) Center of 100 m^2 Sampling Area			20 Day Analysis Results (pCi/g)			
Sample ID	Collection Date	North	East	Sample Size (g)	Ra-226*	+/- (2s)	U-238	+/- (2s)
98RVS001	06/30/98	4813	5588	581.8	1.3	0.2	2.8	1.3
98RVS002	06/30/98	5063	5588	536.7	1.6	0.2	1.4	1.7
98RVS003	06/30/98	5313	5588	538.2	1.7	0.2	2.3	1.1
98RVS004	06/30/98	5313	5088	577.0	1.6	0.2	1.7	0.9
98RVS005	06/30/98	5513	4838	435.8	1.8	0.3	0.0	2.7
98RVS006	06/30/98	5313	4588	597.8	1.5	0.2	2.3	1.3
98RVS007	06/30/98	5063	4588	489.5	1.8	0.2	2.4	1.4
98RVS008	06/30/98	5063	4838	341.3	1.6	0.3	1.0	1.3
98RVS009	06/30/98	5563	4588	645.7	1.5	0.2	1.5	0.8
98RVS010	06/30/98	5563	4838	629.5	1.3	0.2	0.5	1.2
98RVS011	07/01/98	6313	5338	714.6	1.8	0.2	2.4	2.1
98RVS012	07/01/98	6313	5088	612.6	1.8	0.2	2.7	1.8
98RVS013	07/01/98	6313	4838	609.2	1.6	0.2	1.7	1.4
98RVS014	07/01/98	6313	4588	615.0	1.6	0.2	1.5	0.9
98RVS015	07/01/98	6313	4338	638.2	1.4	0.2	1.2	2.0
98RVS016	07/01/98	6063	4558	701.3	1.4	0.2	1.3	0.9
98RVS017	07/01/98	6563	4588	721.5	1.3	0.2	1.4	0.8
98RVS018	07/01/98	6813	4838	767.7	1.5	0.2	3.0	1.2
98RVS019	07/01/98	7063	5088	769.7	1.2	0.2	0.3	1.8
98RVS020	07/01/98	7313	5338	710.8	1.1	0.2	1.1	1.1
98RVS021	07/01/98	7063	5338	712.7	1.0	0.1	0.8	0.8
98RVS022	07/01/98	6563	4838	608.6	1.6	0.2	1.7	0.9
98RVS023	07/01/98	6063	4338	645.4	1.4	0.2	1.3	1.3
98RVS024	07/01/98	6813	5088	671.7	1.6	0.2	0.6	2.0
98RVS025	07/02/98	6563	5088	689.2	1.5	0.2	1.7	1.3
98RVS026	07/02/98	6313	5588	676.0	1.5	0.2	2.2	1.3
98RVS027	07/02/98	6563	5338	679.5	1.4	0.2	0.6	1.1
98RVS028	07/02/98	6813	5338	771.3	0.9	0.1	0.4	1.1
98RVS029	07/02/98	5368	5338	632.5	1.6	0.2	0.8	2.0
98RVS030	07/06/98	4563	4338	619.3	1.7	0.2	1.0	1.8
98RVS031	07/06/98	4563	4588	570.2	1.7	0.2	3.0	2.4
98RVS032	07/06/98	4813	4353	548.3	1.7	0.2	0.9	1.4
98RVS033*	07/07/98	7063	5088	760.5	1.2	0.2	0.6	0.8
98RVS034	07/07/98	4600	5610	704.9	1.5	0.2	1.1	0.8
98RVS035	07/07/98	4563	5338	657.6	1.6	0.2	1.2	1.4
98RVS036	07/07/98	4563	5088	565.0	1.8	0.2	3.6	2.3
98RVS037	07/07/98	4563	4838	525.4	1.8	0.2	2.0	1.1
98RVS038	07/07/98	5063	5088	628.1	1.6	0.2	1.3	0.9
98RVS039	07/07/98	5063	4353	615.1	2.0	0.3	1.5	1.3
98RVS040*	07/07/98	5063	4353	564.1	2.2	0.3	2.3	1.5
98RVS041	07/07/98	4813	4588	560.8	1.7	0.2	1.1	0.9
98RVS042	07/07/98	4813	4838	581.7	1.8	0.2	-0.1	1.5
98RVS043	07/07/98	4813	5088	644.6	1.9	0.2	2.8	2.2
98RVS044	07/07/98	4813	5338	515.8	1.8	0.2	1.5	1.8
98RVS045	07/08/98	5563	5588	671.5	1.4	0.2	1.7	1.1
98RVS046	07/08/98	5813	5588	673.5	1.4	0.2	0.8	1.3
98RVS047	07/08/98	6063	5548	698.7	1.2	0.2	-0.2	1.9
98RVS048	07/08/98	6063	5449	629.0	1.0	0.1	0.7	1.3
98RVS049	07/08/98	5813	5338	610.7	1.2	0.2	0.8	0.9

Exhibit F Final Scil Analysis Results

		Location (ft) Center of 100 m^2 Sampling Area			20 Day Analysis Results (pCi/g)			
Sample ID	Collection Date	North	East	Sample Size (g)	Ra-226*	+/- (2s)	U-238	+/- (2s)
98RVS050	07/08/98	6063	5088	775.0	1.1	0.2	1.4	0.7
98RVS051	07/08/98	5813	4588	742.3	1.3	0.2	1.1	1.1
98RVS052	07/08/98	6063	4838	627.9	1.8	0.2	1.2	1.0
98RVS053	07/08/98	6063	4838	671.8	1.9	0.2	1.5	0.9
98RVS054	07/13/98	4837	4400	208.4	1.8	0.3	3.5	2.0
98RVS055	07/13/98	4970	4334	256.6	2.6	0.4	12.9	4.0
98RVS056	07/13/98	5323	4352	265.5	2.6	0.4	3.1	1.7
98RVS057	07/14/98	5493	4820	684.3	1.8	0.2	3.3	1.4
98RVS058	07/14/98	5894	5437	581.4	48.5	4.9	3.0	4.4
98RVS059	07/16/98	6400	5189	547.8	2.0	0.3	1.3	1.5
98RVS060	07/24/98	BACKGROUND		642.0	1.3	0.2	2.8	1.3

NOTES:

* Duplicate QC Sample.

Ra-226 concentration based upon equilibrated B-214 or Pb-210, whichever was higher.

It is suspected that the Northing on 98RVS005 was incorrectly identified at 5513.

This sample location should have been at 5313 North.

98RVS054 from bottom of one foot deep rut, Survey Unit 35.

98RVS055 Ballast from abandonned rail line, Survey Unit 43.

98RVS056 Ballast from abandonned rail line, Survey Unit 67.

98RVS057 Highest gamma measurement along straight line anomaly, Survey Unit 72.

98RVS058 Residual contamination from source removal location, Survey Unit 91.

98RVS059 Sample taken from material at the edge of the running track, Survey Unit 134.

98RVS060 Background Confirmation Sample.

Exhibit G
Surface Exposure Rates

Exhibit G

EXPOSURE RATES at 1 Meter
at the River Valley School District
Marion, OH

SURVEY UNIT	SURVEY DATA (S) SURFACE*	uR/hr	SD	BACKGROUND DATA (B) uR/hr	SD	DIFFERENCE (S-B)	CRITERIA	PASS?
001	BRICK	12.5	1.6	13.7	1.1	-1.2	6.1	YES
002	GRASS	11.5	0.2	10.0	1.1	1.6	6.1	YES
003	GRASS	10.9	0.2	10.0	1.1	0.9	6.1	YES
004	GRASS	10.9	0.2	10.0	1.1	0.9	6.1	YES
005	GRASS	10.7	0.2	10.0	1.1	0.8	6.1	YES
006	GRASS	10.7	0.2	10.0	1.1	0.7	6.1	YES
007	GRASS	11.3	0.3	10.0	1.1	1.3	6.1	YES
008	GRASS	11.4	0.2	10.0	1.1	1.4	6.1	YES
009	GRASS	10.9	0.3	10.0	1.1	0.9	6.1	YES
010	GRASS	10.8	0.1	10.0	1.1	0.9	6.1	YES
011	GRASS	10.8	0.4	10.0	1.1	0.8	6.1	YES
012	GRASS	10.5	0.1	10.0	1.1	0.6	6.1	YES
013	GRASS	11.1	0.1	10.0	1.1	1.2	6.1	YES
014	GRASS	10.9	0.2	10.0	1.1	0.9	6.1	YES
015	GRASS	10.8	0.3	10.0	1.1	0.9	6.1	YES
016	GRASS	11.5	0.3	10.0	1.1	1.5	6.1	YES
017	GRASS	10.7	0.6	10.0	1.1	0.8	6.1	YES
018	GRASS	10.8	0.2	10.0	1.1	0.9	6.1	YES
019	GRASS	10.6	0.1	10.0	1.1	0.7	6.1	YES
020	GRASS	10.6	0.2	10.0	1.1	0.6	6.1	YES
021	GRASS	10.7	0.2	10.0	1.1	0.8	6.1	YES
022	GRASS	10.9	0.7	10.0	1.1	0.9	6.1	YES
023	GRASS	11.5	0.4	10.0	1.1	1.6	6.1	YES
024	GRASS	10.2	0.6	10.0	1.1	0.2	6.1	YES
025	GRASS	10.5	0.2	10.0	1.1	0.6	6.1	YES
026	GRASS	10.6	0.2	10.0	1.1	0.7	6.1	YES
027	GRASS	10.6	0.2	10.0	1.1	0.6	6.1	YES
028	GRASS	10.8	0.2	10.0	1.1	0.8	6.1	YES
029	GRASS	11.2	0.7	10.0	1.1	1.2	6.1	YES
030	GRASS	11.9	0.2	10.0	1.1	1.9	6.1	YES
031	GRASS	11.7	0.3	10.0	1.1	1.7	6.1	YES
032	GRASS	10.6	0.4	10.0	1.1	0.6	6.1	YES
033	GRASS	10.6	0.2	10.0	1.1	0.6	6.1	YES
034	GRASS	10.5	0.1	10.0	1.1	0.5	6.1	YES
035	GRASS	10.7	0.3	10.0	1.1	0.8	6.1	YES
036	BRICK	13.3	1.0	13.7	1.1	-0.4	6.1	YES
037	GRASS	10.7	0.5	10.0	1.1	0.7	6.1	YES
038	GRASS	12.2	0.5	10.0	1.1	2.2	6.1	YES
039	GRASS	11.8	0.2	10.0	1.1	1.8	6.1	YES
040	GRASS	10.7	0.2	10.0	1.1	0.7	6.1	YES
041	GRASS	10.5	0.2	10.0	1.1	0.5	6.1	YES
042	GRASS	10.3	0.2	10.0	1.1	0.3	6.1	YES
043	GRASS	10.8	0.4	10.0	1.1	0.9	6.1	YES
044	GRASS	11.7	1.0	10.0	1.1	1.7	6.1	YES

* BRICK = brick surface
GRASS = >50% grass
GRASS CROSS = <50% grass
OTHER = >75% concrete, gravel, or asphalt

EXPOSURE RATES at 1 Meter
at the River Valley School District
Marion, OH

SURVEY UNIT	SURVEY DATA (S) SURFACE*	SURVEY DATA (S) uR/hr	SURVEY DATA (S) SD	BACKGROUND DATA (B) uR/hr	BACKGROUND DATA (B) SD	DIFFERENCE (S-B)	CRITERIA	PASS?
045	GRASS	11.5	0.5	10.0	1.1	1.5	6.1	YES
046	GRASS	11.4	0.2	10.0	1.1	1.4	6.1	YES
047	GRASS	10.4	0.2	10.0	1.1	0.4	6.1	YES
048	GRASS	10.7	0.3	10.0	1.1	0.7	6.1	YES
049	GRASS	9.7	0.6	10.0	1.1	-0.3	6.1	YES
050	OTHER	9.4	1.0	10.0	1.1	-0.6	6.1	YES
051	GRASS	10.5	0.6	10.0	1.1	0.5	6.1	YES
052	GRASS	11.4	0.1	10.0	1.1	1.4	6.1	YES
053	GRASS	10.3	0.4	10.0	1.1	0.3	6.1	YES
054	GRASS	10.6	0.3	10.0	1.1	0.7	6.1	YES
055	GRASS	10.6	0.2	10.0	1.1	0.6	6.1	YES
056	GRASS CROSS	10.3	0.7	10.0	1.1	0.3	6.1	YES
057	GRASS	9.6	0.9	10.0	1.1	-0.4	6.1	YES
058	GRASS	11.0	0.5	10.0	1.1	1.1	6.1	YES
059	GRASS	11.3	0.3	10.0	1.1	1.4	6.1	YES
060	GRASS	10.4	0.2	10.0	1.1	0.5	6.1	YES
061	GRASS	10.3	0.5	10.0	1.1	0.3	6.1	YES
062	GRASS	11.0	0.4	10.0	1.1	1.0	6.1	YES
063	OTHER	9.0	0.8	10.0	1.1	-0.9	6.1	YES
064	GRASS	10.8	0.2	10.0	1.1	0.9	6.1	YES
065	GRASS	11.4	0.2	10.0	1.1	1.4	6.1	YES
066	GRASS	10.5	0.2	10.0	1.1	0.5	6.1	YES
067	GRASS	11.1	0.3	10.0	1.1	1.1	6.1	YES
068	GRASS	10.9	0.6	10.0	1.1	0.9	6.1	YES
069	GRASS	11.3	1.3	10.0	1.1	1.3	6.1	YES
070	GRASS	11.1	1.0	10.0	1.1	1.1	6.1	YES
071	GRASS	11.5	0.2	10.0	1.1	1.6	6.1	YES
072	GRASS	11.5	0.2	10.0	1.1	1.5	6.1	YES
073	GRASS	10.2	0.3	10.0	1.1	0.3	6.1	YES
074	GRASS	10.7	0.9	10.0	1.1	0.7	6.1	YES
075	BRICK	12.0	1.7	13.7	1.1	-1.7	6.1	YES
076	GRASS	11.3	0.6	10.0	1.1	1.3	6.1	YES
077	GRASS	11.0	0.8	10.0	1.1	1.0	6.1	YES
078	GRASS	10.6	0.5	10.0	1.1	0.6	6.1	YES
079	GRASS	10.4	0.4	10.0	1.1	0.4	6.1	YES
080	GRASS	10.4	0.5	10.0	1.1	0.4	6.1	YES
081	BRICK	12.1	1.9	13.7	1.1	-1.6	6.1	YES
082	OTHER	9.3	0.7	10.0	1.1	-0.6	6.1	YES
083	GRASS	11.4	0.2	10.0	1.1	1.5	6.1	YES
084	GRASS	10.8	0.4	10.0	1.1	0.8	6.1	YES
085	GRASS	10.6	0.3	10.0	1.1	0.7	6.1	YES
086	GRASS	10.9	0.3	10.0	1.1	0.9	6.1	YES
087	GRASS CROSS	9.9	0.8	10.0	1.1	0.0	6.1	YES
088	OTHER	8.7	0.2	10.0	1.1	-1.3	6.1	YES

* BRICK = brick surface
GRASS = >50% grass
GRASS CROSS = <50% grass
OTHER = >75% concrete, gravel, or asphalt

EXPOSURE RATES at 1 Meter
at the River Valley School District
Marion, OH

SURVEY	SURVEY DATA (S)			BACKGROUND DATA (B)		DIFFERENCE		
UNIT	SURFACE*	uR/hr	SD	uR/hr	SD	(S-B)	CRITERIA	PASS?
089	GRASS	10.3	0.6	10.0	1.1	0.3	6.1	YES
090	GRASS	10.4	0.4	10.0	1.1	0.4	6.1	YES
091	GRASS	11.1	0.2	10.0	1.1	1.1	6.1	YES
092	GRASS	9.5	0.7	10.0	1.1	-0.5	6.1	YES
093	OTHER	8.2	0.1	10.0	1.1	-1.7	6.1	YES
094	GRASS	11.3	0.9	10.0	1.1	1.4	6.1	YES
095	GRASS	10.5	0.2	10.0	1.1	0.6	6.1	YES
096	GRASS	10.5	0.1	10.0	1.1	0.5	6.1	YES
097	GRASS	10.2	0.3	10.0	1.1	0.3	6.1	YES
098	GRASS	10.8	0.7	10.0	1.1	0.8	6.1	YES
099	OTHER	8.7	0.6	10.0	1.1	-1.2	6.1	YES
100	GRASS	9.8	0.6	10.0	1.1	-0.2	6.1	YES
101	GRASS	10.8	0.3	10.0	1.1	0.8	6.1	YES
102	GRASS	10.2	0.6	10.0	1.1	0.2	6.1	YES
103	GRASS CROSS	9.3	0.7	10.0	1.1	-0.7	6.1	YES
104	OTHER	8.4	0.2	10.0	1.1	-1.5	6.1	YES
105	OTHER	8.6	0.1	10.0	1.1	-1.3	6.1	YES
106	GRASS	9.9	0.6	10.0	1.1	-0.1	6.1	YES
107	GRASS	10.5	0.3	10.0	1.1	0.5	6.1	YES
108	GRASS	10.1	0.7	10.0	1.1	0.1	6.1	YES
109	GRASS CROSS	9.4	0.8	10.0	1.1	-0.5	6.1	YES
110	GRASS CROSS	9.4	0.8	10.0	1.1	-0.5	6.1	YES
111	GRASS	9.8	0.6	10.0	1.1	-0.2	6.1	YES
112	GRASS	10.0	0.4	10.0	1.1	0.0	6.1	YES
113	GRASS	10.4	0.4	10.0	1.1	0.4	6.1	YES
114	GRASS	10.1	0.7	10.0	1.1	0.1	6.1	YES
115	GRASS	9.9	0.9	10.0	1.1	0.0	6.1	YES
116	GRASS	10.5	0.2	10.0	1.1	0.5	6.1	YES
117	OTHER	9.9	0.8	10.0	1.1	-0.1	6.1	YES
118	GRASS	10.8	0.5	10.0	1.1	0.9	6.1	YES
119	GRASS	10.1	0.2	10.0	1.1	0.1	6.1	YES
120	GRASS CROSS	9.5	0.7	10.0	1.1	-0.5	6.1	YES
121	GRASS	9.9	0.7	10.0	1.1	0.0	6.1	YES
122	GRASS	10.3	0.7	10.0	1.1	0.3	6.1	YES
123	GRASS	10.5	0.2	10.0	1.1	0.6	6.1	YES
124	GRASS	10.5	0.1	10.0	1.1	0.5	6.1	YES
125	GRASS	10.2	0.4	10.0	1.1	0.2	6.1	YES
126	GRASS	10.9	0.4	10.0	1.1	0.9	6.1	YES
127	GRASS	10.3	0.6	10.0	1.1	0.4	6.1	YES
128	GRASS	9.7	0.7	10.0	1.1	-0.3	6.1	YES
129	GRASS CROSS	8.9	0.6	10.0	1.1	-1.1	6.1	YES
130	GRASS	10.1	0.9	10.0	1.1	0.1	6.1	YES
131	GRASS	10.5	0.3	10.0	1.1	0.5	6.1	YES
132	GRASS	10.6	0.5	10.0	1.1	0.6	6.1	YES

* BRICK = brick surface
GRASS = >50% grass
GRASS CROSS = <50% grass
OTHER = >75% concrete, gravel, or asphalt

EXPOSURE RATES at 1 Meter

at the River Valley School District

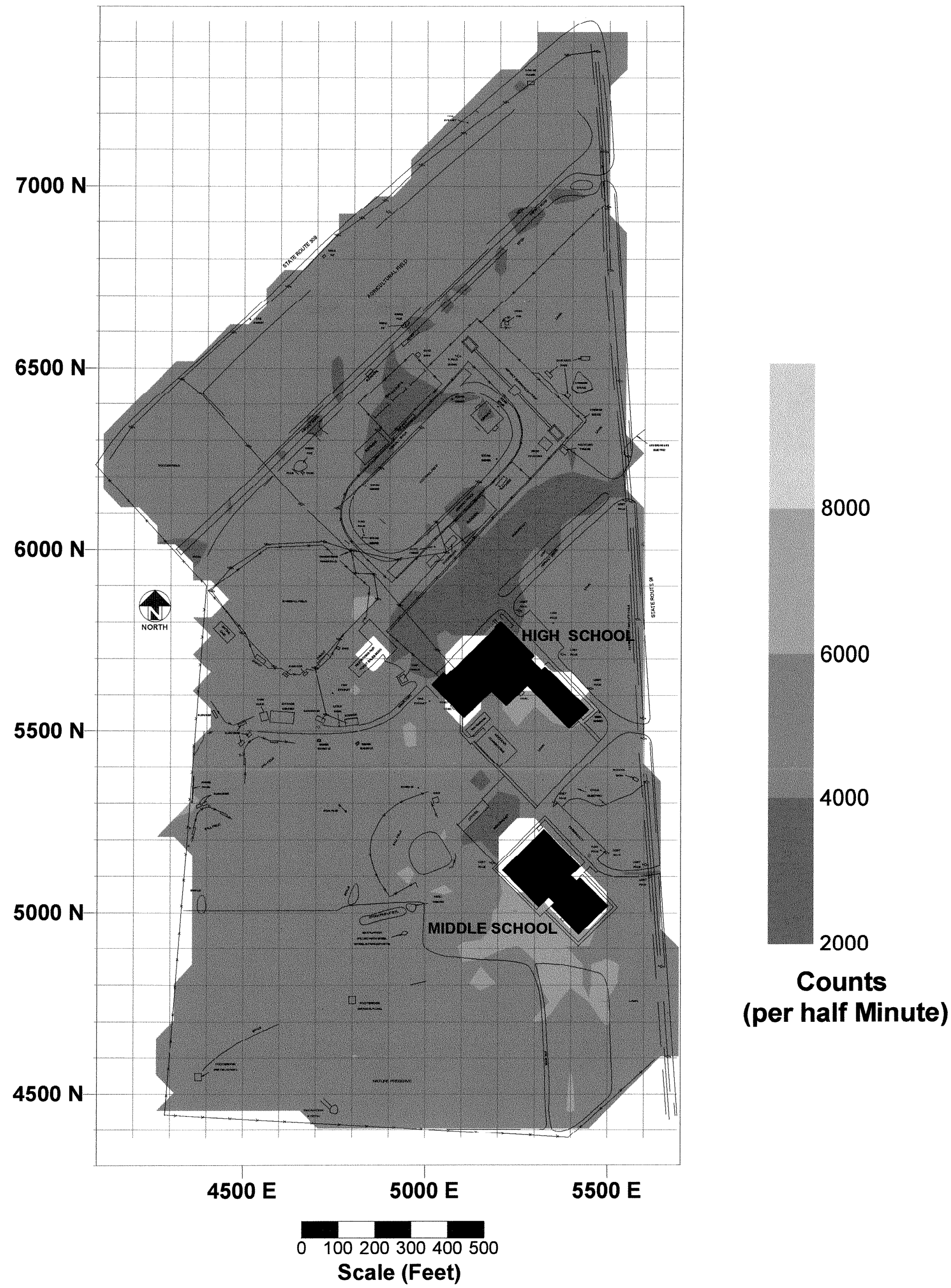
Marion, OH

SURVEY UNIT	SURVEY DATA (S) SURFACE*	uR/hr	SD	BACKGROUND DATA (B) uR/hr	SD	DIFFERENCE (S-B)	CRITERIA	PASS?
133	GRASS	10.9	0.2	10.0	1.1	0.9	6.1	YES
134	GRASS	9.3	0.9	10.0	1.1	-0.7	6.1	YES
135	OTHER	8.9	0.9	10.0	1.1	-1.1	6.1	YES
136	GRASS	9.8	0.9	10.0	1.1	-0.1	6.1	YES
137	GRASS	10.4	0.3	10.0	1.1	0.4	6.1	YES
138	GRASS	9.5	0.2	10.0	1.1	-0.5	6.1	YES
139	GRASS	10.1	0.3	10.0	1.1	0.1	6.1	YES
140	GRASS	10.0	0.3	10.0	1.1	0.0	6.1	YES
141	GRASS	9.8	0.7	10.0	1.1	-0.2	6.1	YES
142	GRASS	10.2	0.3	10.0	1.1	0.2	6.1	YES
143	GRASS	10.3	0.3	10.0	1.1	0.3	6.1	YES
144	GRASS	10.2	0.3	10.0	1.1	0.2	6.1	YES
145	GRASS	9.7	0.3	10.0	1.1	-0.3	6.1	YES
146	GRASS	9.8	0.2	10.0	1.1	-0.2	6.1	YES
147	GRASS	9.4	0.7	10.0	1.1	-0.6	6.1	YES
148	GRASS	10.4	0.3	10.0	1.1	0.4	6.1	YES
149	GRASS	10.2	0.3	10.0	1.1	0.2	6.1	YES
150	GRASS	10.0	0.4	10.0	1.1	0.1	6.1	YES
151	GRASS	9.6	0.1	10.0	1.1	-0.4	6.1	YES
152	GRASS	9.6	0.7	10.0	1.1	-0.3	6.1	YES
153	GRASS	9.9	0.3	10.0	1.1	-0.1	6.1	YES
154	GRASS	9.8	0.3	10.0	1.1	-0.2	6.1	YES
155	GRASS	10.1	0.3	10.0	1.1	0.1	6.1	YES
156	GRASS	9.7	0.2	10.0	1.1	-0.3	6.1	YES
157	GRASS	9.7	0.6	10.0	1.1	-0.3	6.1	YES
158	GRASS	9.8	0.4	10.0	1.1	-0.2	6.1	YES
159	GRASS	9.2	0.6	10.0	1.1	-0.7	6.1	YES
160	GRASS	9.7	0.5	10.0	1.1	-0.3	6.1	YES
161	GRASS	9.7	0.2	10.0	1.1	-0.3	6.1	YES
162	GRASS	9.8	0.3	10.0	1.1	-0.1	6.1	YES
163	GRASS	10.0	0.2	10.0	1.1	0.0	6.1	YES
164	GRASS	9.7	0.3	10.0	1.1	-0.2	6.1	YES
165	GRASS	10.0	0.2	10.0	1.1	0.0	6.1	YES
166	GRASS	10.0	0.6	10.0	1.1	0.0	6.1	YES
167	GRASS	9.4	0.2	10.0	1.1	-0.5	6.1	YES
168	GRASS	9.5	0.3	10.0	1.1	-0.5	6.1	YES
169	GRASS	9.7	0.5	10.0	1.1	-0.3	6.1	YES
170	GRASS	10.0	0.5	10.0	1.1	0.1	6.1	YES
171	GRASS	9.8	0.2	10.0	1.1	-0.2	6.1	YES
	AVERAGES	10.4	0.4			0.3		

* BRICK = brick surface
GRASS = >50% grass
GRASS CROSS = <50% grass
OTHER = >75% concrete, gravel, or asphalt

RIVER VALLEY SCHOOL - RADIOLOGICAL INVESTIGATION - GAMMA SCAN DATA

SAFETY AND ECOLOGY CORPORATION KNOXVILLE, TENNESSEE	U. S. ARMY CORPS OF ENGINEERS LOUISVILLE DISTRICT
DRAWN BY: LAWHON & ASSOCIATES, Inc. WESTERVILLE, OHIO	MONTGOMERY WATSON DETROIT, MICHIGAN



RIVER VALLEY SCHOOL - RADIOLOGICAL INVESTIGATION - EXPOSURE RATE DATA

SAFETY AND ECOLOGY CORPORATION KNOXVILLE, TENNESSEE	U. S. ARMY CORPS OF ENGINEERS LOUISVILLE DISTRICT
DRAWN BY: LAWHON & ASSOCIATES, Inc. WESTERVILLE, OHIO	MONTGOMERY WATSON DETROIT, MICHIGAN